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Department of Geography and Environmental Studies

Spatio – Temporal Assessment of Road Traffic Accident in Mekelle City

By

Girmay Giday Kindaya

A Thesis Submitted in Partial Fulfillment of the Requirement for the Masters of Science Degree in Geography and Environmental Studies:
Specialization in GIS and Remote Sensing

Advisors

Atkilt Girma (Drs.)

Solomon Hishe (MSc.)

January, 2014

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DECLARATION

This is to certify that this thesis entitled "**Spatio-Temporal Assessment of Road Traffic Accident in Mekelle City**" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Geography and Environmental Studies with Specialization in **GIS and Remote Sensing** at Mekelle University, department of Geography and Environmental Studies done by **Girmay Giday Kindaya, CSSL/PS006/03** is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for an award of any degree or diploma to the best of our knowledge and belief.

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Let everything that has breath praise the Lord.
Psalms 150:6

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Girmay Giday

Mekelle, January- 2014

List of Acronyms and Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
CSA	Central Statistics Agency
DALY	Disability Adjusted Life Year
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
g/dl	Gram per Deciliter
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GNP	Gross National Product
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
IRTAD	International Road Traffic and Accident Database
KDE	Kernel Density Estimation
Km/h	Kilometer per Hour
MAO	Mekelle Administration Office
MZPTO	Mekelle Zone Police Traffic Office
NMA	National Meteorological Agency
RSDP	Road Sector Development Program
RTA	Road Traffic Accident
RTAs	Road Traffic Accidents
SPSS	Statistical Package for the Social Sciences
TRB	Transport Research Board

TRPC	Tigray Region Police Commission
UK	United Kingdom
UN	United Nations
USD/US$	United States Dollar
WB	World Bank
WHO	World Health Organization

ABSTRACT

Road Traffic Accidents are the foremost causes of death and disability globally, with a top-heavy number occurring in developing countries. Road Traffic Accidents are currently ranked ninth globally amongst the leading causes of disability adjusted life years lost and the ranking is anticipated to rise to rank third by 2020. Over 1.2 million people die every year in the world's roads, and between 20 and 50 million grieve non-fatal injuries. The direct financial costs of global road crashes have been estimated at US$ 518 billion, with the costs in low-income countries – estimated at US$ 65 billion.

The aim of this study is to assess Road Traffic Accident related issues of Mekelle City in terms of time and space from 2008 to 2011. The pivotal data necessary for the study was collected from the daily Road Traffic Accident records format of the city. Furthermore, additional information required for the study was collected through interviewing traffic police officers. The locations of frequent Road Traffic Accident occurrences were specified using Google Earth. The X - Y coordinates of Road Traffic Accident Spots were added to ArcGIS 9 software via DNRGPS 6.0.0.8 Application software. Data analysis was made using ArcGIS 9 and SPSS version 19. The results were presented in the form of line graphs, crosstabs, column graphs, pie charts, figures and spatial and spatio-temporal maps.

The result of the study revealed that, 1275 Road Traffic Accidents have occurred in the city in the study period. About 624 people became Road Traffic Accident casualties and road crashes cost the city ETB 10,265,977.6 from 2008 to 2011. Unevenly distributed 1161 spatially identified Road Traffic Accidents have occurred in 247 different Road Traffic Accident spots of the city in the study period. Besides, 34 Road Traffic Accident Black Spots, top 10 as well as 4 consistent Road Traffic Accident Black Spots have been identified in the city.

It was concluded that, the frequency of occurrence of Road Traffic Accidents and number of casualties is escalating from time to time and the city is losing a lot of its financial wealth due to Road Traffic Accidents. As a result, road users must be made aware of the disaster, road infrastructure should be developed, stakeholders should significantly participate in road safety management and authorities should take actions to curb the anguish of Road Traffic Accidents in Mekelle City.

Key Words: *Road Traffic Accident, Road Traffic Accident Spots, Road Traffic Accident Black Spots, Road Traffic Accident Casualties*

CHAPTER ONE

1. INTRODUCTION

1.1 General Introduction

There is uneven distribution of natural resources on the earth's surface. The insufficiency of different goods and services exists in different places around the world. In addition, there is a difference in specialization in the production of varieties of commodities and services. As a result of these conditions and other related drives people exchange what they have produced with what they need regardless of the distance between them and their partners in trade. Consequently, people have to move from place to place to do so.

Any movement of people for any perseverance using different means is known as transportation. As indicated in Bamford and Robinson (1978),"Transport by definition infers a movement, and each individual from an early age owns his own "built-in" capability to travel, although within a restricted area". Moreover, to express the crucial part of transport Bamford and Robinson (1978) generalized that it is difficult to conceive of a situation where transport does not play a major role in the life of an individual.

It is obvious that, among all modes of transportation, road transport is the nearby means of conveyance. Road Transport's major advantage compared with others is its elasticity, which permits it to function from door-to-door over short distances at the most competitive prices (Bamford and Robinson 1978; Wough 1990). In Africa over 80% of goods and people are transported by roads while in Ethiopia road transport accounts for over 90% of all the inter-urban freight and passenger movements in the country (Kifle 1996).

Transportation is one of the basic necessities for the apposite functioning of societies as its demand is greatly related to the movement of people from one place to another. Since every bustle of human being has its own consequences (positive or negative) transport is not an exception to this circumstance. In connotation to this Rallis (1997) have stated that the constraints associated with transport include the risk of traffic mobbing, traffic coincidence, pollution, noise, and the like. Road Traffic Accidents

(RTAs) are among the most damaging environmental effects, which have caused from transportation development. Road safety, therefore, urges serious concern worldwide.

According to Ajit and Ripunjoy (2004) RTAs have turned out to be a huge global public health and development problem killing almost 1.2 million people a year and wounding or disabling about 20-50 million people more; the combined population of five of the world's large cities. The statistical profile reflects that in 2002, RTAs charged the global community about US $ 518 billion.

In similar manner WHO (2004) reports that; Road traffic injuries are a major but neglected global public health disruptive, necessitating concerted sweats for actual and sustainable prevention. Of all the systems that people have to pact with on a daily basis, road transport is the most composite and the most dangerous. The catastrophe behind these figures regularly attracts less media courtesy than other, less recurrent but more unusual types of tragedy.

Though the above researches focused on the entire nature and disastrous effect of Road Traffic Accident (RTA) at a global scale, this study will focus on assessing the general characteristics of RTA, places of frequent road traffic accident occurrences, trend, causes and impacts of RTAs in Mekelle City.

1.2 Statement of the Problem

The road traffic injury problem has started to occur before the coming of the car. Nonetheless, it was with the car and afterwards trucks, buses and other vehicles which the misery intensified swiftly. The first road crash was allegedly writhed by a cyclist on 30 May 1896 in New York city, shadowed few months later by the first fatality, a pedestrian in London (Gibson 1975; Joseph 1980). Although the meticulous number will never be known, the frequency of fatalities was conventionally assessed to have reached an aggregate total of 25 million by 1997 (WHO 2004). It is after those historical events that the road traffic crashes have sustained to this day to exact their peal.

Despite the extent and severity of the accident is different, it has a global scope in nature. Road Traffic Accident is the prominent cause of death by injury in the world. According to UN (2011), above 1.2 million people die in the world's roads every year. In addition to this, about 65% of the total deaths in road crashes in the world include pedestrians, 35% of these are children (UN 2011). In line with this report, WHO (2011) described that 145 people die at every hour of every day, someone is killed or utterly hurt in every six seconds of every minute, a million exceeding people lost their lives

each year, one in five of whom is a child merely because of RTAs. Likewise, WHO (2004) described an average of 3,242 persons were vanishing each day around the globe due to road traffic injuries.

The impact of road transport accident over the socio – economic aspects of Africa is even much worse. Africa, a continent of people who have long been in a struggle for poverty reduction and for the security of other basic needs, are nowadays seem to face another challenge, that is devastating RTA. In another look, UN (2011) shows that RTA costs Africa $10 billion annually and remains the second leading cause of death for 5 – 44 age - groups around the continent.

Ethiopia contributes much to the misery of RTA in Africa. At least one person is killed from every five car coincidences occurring in Ethiopia. Eventually the most shocking and terrible impact of RTA in Ethiopia is also stated in UN (2009), as over half of RTA deaths in Ethiopia involve pedestrians, of whom 20% are children younger than 18 years old. Similarly, Tesema (2005) have stated that, in Ethiopia, above 1800 people died while around 7000 were crippled or injured in 2003 due to RTA. Moreover, the death rate is 136 per 10,000 vehicles in the country. Likewise, according to Odero (2004) pedestrians account for the highest proportion of road fatalities in nearly all African countries, ranging between 31% in Zimbabwe and 51% in Ethiopia.

The government of Ethiopia is investing huge budget on road transport construction and related infrastructures aiming at increasing the quality of roads, making communication much easier and dissemination of import and export trade better so as to maintain the current rapidly growing economy of the nation. UN (2010) stated that, high quality asphalt roads and rural community roads have been constructed all over the country. In addition to this, UN (2009) proclaimed that: Recognizing the importance of the road transport, the Government of Ethiopia has launched a Road Sector Development Program (RSDP) since 1997 which focused on upgrading and rehabilitating the existing road network, expanding the road network, and providing regular maintenance. Since then, the condition of roads has improved and the network which was about 26,550 km at the beginning of RSDP in 1997 has improved to 44,359 km by 2008.

Notwithstanding, the above progressive reports of improvement in the quality and accessibility of road transportation sector in Ethiopia, RTA remains to be one of the precarious problems of the road transport in Ethiopia. A study of RTA by UN (2009) conducted in Ethiopia reveals that, Road traffic accident in Ethiopia is a cause of significant losses of human and economic resources. In the year 2007/08, police stated

15,086 accidents which caused the fatalities of 2,161 lives and over Ethiopian Birr (ETB) 82 million (US$7.3 million).

The report of TRPC (2010) officially reveals that, RTA slurped Tigray region about ETB 15,327,932 in 2010. According to the cost estimate of property damage of RTA as collected from RTA document of Mekelle City traffic office, the total cost of RTA of the city was ETB 2,254,981.9 in 2008, 2,196,355.7 in 2009, 1,985,420.0 in 2010 and 3,829,220.0 in 2011. Children under the age of 18 and adults between ages of 18 – 50 are the prior victims of RTA in Mekelle City. The TRPC (2010), hearsays that, out of 221 death caused by RTA in 2010 in the region, 51 (23.07%) of the victims were children under the age of 18 and 156 (70.58%) were adults between ages of 18 – 50 years old. In addition to this above 442 were heavily injured and other 385 have got minor injury in the same year from all age groups in the region.

Mekelle City, the main focus of this study, contributed 37 out of 221 death cases in Tigray region by RTA in the year 2010. Not only this but also out of the total occurrence of RTA in Tigray region by the year 2010, 84 (19%) of the heavy injuries, 79 (20.5%) of minor injuries and ETB 1,985,420.0 (12.95%) of property damages have been recorded in Mekelle City. By 2011, 26 out of 303 fatal accidents, 59 out of 415 serious injuries and 24 out of 361 minor injuries in Tigray region have been recorded in Mekelle City. In terms of financial cost of RTA in 2011, Mekelle City shares ETB 3,829,220.0 (14.45%) of the total ETB 26,485,650 of Tigray region. This shows that, the city is very much vulnerable to road transport related accidents than any other zone in Tigray region. Moreover, Based on MZPTO (2007) the number of vehicles in the city before two decades was insignificant, but in 2007/08, it has increased to 6989. In addition to this, MZPTO (2007) report shows that, the RTA occurring in the city with some exceptions are increasing form time to time. The total RTA occurred in the years 2003, 2004, 2005, 2006 and 2007 was 92, 78, 119, 111 and 116 respectively (MZPTO 2007). However, the number of RTA occurrences in the city in the years 2008, 2009, 2010 and 2011 has increased in to 288, 342, 322 and 323 respectively.

Some studies, prior to this study, have been conducted focusing on the issue of RTA in Mekelle City by different dignitaries. However, almost all those studies were not well organized and failed to plot RTA risk areas in the city, failed to prepare data base of RTA occurrences and were unable to forward applicable recommendations in relation to the financial and infrastructural capabilities of Mekelle City. Here we believe that the RTA issue of Mekelle City did not get enough attention from academicians.

While this study is in the same universe with the preceding studies, it will focus mainly on describing the general characteristics of RTA, mapping RTA risk areas, identifying main causes, examining spatio – temporal trend of RTA, analyzing impacts of RTA in the city and forwarding new and applicable recommendations.

So far, we did not find any study that assessed the Spatio – temporal relations of RTA for Mekelle City. The rationale of this study therefore is to describe the characteristics of RTA, map places of frequent RTA occurrences, examine the spatio – temporal trend of RTA, identify major causes and analyze the socio – economic impacts of RTAs and thereby offer possible suggestions which could help to minimize the disaster in the study area.

Thus, RTA is problem in Ethiopia and specifically in Mekelle City which is long been threatening the socio – economic endeavor. With this research we set out to assess the RTA spatially and temporally considering its relevance to planners, policy makers, stakeholders and the community at large. This research will thus be the first of its kind for Mekelle City.

1.3 Objective of the Study

1.3.1 General Objective

The main objective of the research is to study Road Traffic Accident related issues in Mekelle City in terms of time and space.

1.3.2 Specific Objectives

The specific objective of the study is to:

- Describe the general characteristics of RTA in Mekelle City.
- Map the spatio-temporal distribution of RTA Spots and RTA Black Spots in Mekelle City.
- Examine the trend of Road Traffic Accident in Mekelle City.
- Identify major causes of Road Traffic Accident occurrence in Mekelle City.
- Analyze the socio – economic impacts of Road Traffic Accident in Mekelle City.
- Propose appropriate interventions which could help to reduce the Road Traffic Accident occurrences and to minimize RTA socio – economic impacts in Mekelle City.

1.4 Research Questions

This research was conducted to answer the following Basic questions.

1. What characterizes Road Traffic Accidents in Mekelle City?
2. Where do frequent Road Traffic Accidents occur in Mekelle City?
3. What is the trend of Road Traffic Accident occurrence in Mekelle City?
4. What are the major causes and contributory factors for the occurrence of Road Traffic Accidents in Mekelle City?
5. What social and economic costs have been incurred due to road traffic accidents in Mekelle City?
6. What possible appropriate interventions can be recommended for Mekelle City RTA to minimize RTA socio-economic impacts?

1.5 Significance of the Study

This study is mainly concerned with the assessment of RTA in Mekelle City. Emphasis is given to mapping; examining, identifying and analyzing the RTA risk areas, trend, cause, and impact of RTA in the city respectively. Therefore, the study is significant for the following reasons:

- Even though the study is limited to a single city in the country, the results to be obtained from this research could be helpful in launching initiations in studying the complex problems of urban road transport in general and RTA in particular.
- The verdicts attained from the study will be helpful to gain valuable data and information about the RTA black spots, trend, cause and impact of RTA in the city, which in turn, could help to develop countermeasures that could reduce the frequency and severity of road traffic accidents.
- The study will have paramount importance to the government, municipal authorities and the community in the city to determine the need for road improvements and vehicle inspections.
- It can be used as one source of information for those institutions concerned with road safety management and helps to improve the quality of decision-making in urban road transport safety planning.
- The study will be used as a bench mark information to those scholars who want to conduct future detailed studies on RTA, road safety and other related issues.

1.6 Scope of the Study

This particular research focuses on the issues and implications of RTA in all of the seven Sub-cities of Mekelle City. The results, findings, discussions and generalizations of the study will therefore be preliminarily for the study area.

The availability and reliability of the information employed in any study is very important which will have instrumental impact later on the precision of the results and conclusions. This study mainly used Mekelle City RTA data and information of 4 years (2008 - 2011) which is collected from the RTA archives of Mekelle City Traffic Office and other offices and stake holders concerned with the issues of RTA and road safety.

1.7 Limitation of the Study

This study lucks to obtain fully completed data related to RTA. However, several data was obtained from Mekelle City Traffic Office, Tigray region police commission, Mekelle City road transport and construction office and Tigray region bureau of finance and economic development. Some irregularities exist in the data. Especially the RTA data of Mekelle City contain a number of missing and incomplete data elements. The main sources of inconsistence in the RTA data of the city were due to limitations and erratic reporting made by the traffic polices and RTA investigating officers at the data gathering and recording level mainly due to lack of knowhow. In addition to this, before 2008, RTA data of the city were compiled by the sub-cities traffic office separately. However, after the introduction of the Business Process Reengineering Program in the whole country; the RTA data of the city was made to be compiled in one and therefore some RTA data files of the city which contained RTA data of 2008 and 2009 were lost during the transformation process. Consequently, some RTA data of the city have lost part of their entities and others were totally lost. Furthermore, the data was available in hard copy and lack Global Positioning System (GPS) coordinate data. However, the data contained names of approximate location of the RTA. We identified the location of the RTA sites from Google earth images. Thus, the spatial locations of the RTA are approximate.

1.8 Organization of the Paper

This paper is organized in to six chapters. The first chapter introduces the study with general introduction, statement of the problem, objective of the study, basic research questions, significance of the study, scope of the study, limitation of the study and standard definition of basic terms. The second chapter discussed about the review of related literatures regarding definition and concepts of RTA, global and regional trend of RTA, causes of RTA occurrences, economic and social impacts of RTA, RTA black spot definition and treatment and an overview of RTA in Ethiopia. The third chapter encompasses description of the study area in terms of location and administrative setup, demographics characteristics, topography, climate and road network and infrastructure. The fourth chapter comprises materials used and methods applied in steering the entire work. The fifth chapter presents detailed results and discussions of the study while the sixth chapter embraces conclusion and recommendations.

1.9 Standard Definition of Basic Terms

Terms related to RTA can have different definitions in different places. However, (WHO 2010); Alister and Simon (2011) have quoted the following as standard definitions of basic terms of RTA.

Accident: Involves personal injury occurring on the public highway (including footways) involving at least one road vehicle or a vehicle in collision with a pedestrian and which becomes known to the police within 30 days.

Damage only accident: is the one as a result of which no person is injured only one or more vehicles involved in the accident are damaged.

Disability Adjusted Life Years: The years lost by an individual because he or she is disabled as a result of being involved in a Traffic Accident.

Fatal accident: Accident involving at least one fatal casualty.

Fatal injury/ casualty: Injury causes death within 30 days of the accident.

Injury: Physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy. It can be a bodily lesion resulting from acute exposure to excessive energy or impairment of function resulting from lack of vital elements.

Road motor vehicle: A road vehicle fitted with an engine providing its sole means of propulsion, which is normally used for carrying persons or goods, or for drawing (on the road), vehicles used for the carriage of persons or goods.

Road network: All roads in a given area.

Road traffic accident black spots: Places or cites where frequent road traffic accidents occur.

Road traffic accident spots: Places or cites where even a single RTA has occurred regardless of its frequency or severity level of its consequence in a given specified period.

Road traffic crash: A collision or incident involving at least one road vehicle in motion, on a public road or private road to which the public has right of access. Included are: collisions between road vehicles; between road vehicles and pedestrians; between road vehicles and animals or fixed obstacles and with one road vehicle alone. Included are collisions between road and rail vehicles. Multi-vehicle collisions are counted as only one crash provided that any successive collisions happen within a very short time period.

Road traffic injury (or casualty): A person who has sustained physical damage (i.e. injury) as a result of a road traffic crash.

Road traffic: Any movement of a road vehicle on a given road network.

Road transport: Any movements of goods and/or passengers using a road vehicle on a given road network.

Road user: a person using any part of the road system as a non-motorized or motorized transport user.

Road vehicle: A vehicle running or drawn on wheels intended for use on roads.

Road: Line of communication (travelled way) open to public traffic, primarily for the use of road motor vehicles, using a stabilized base other than rails or air strips. Included are paved roads and other roads with a stabilized base, e.g. gravel roads. Roads also cover streets, bridges, tunnels, supporting structures, junctions, crossings and interchanges.

Serious accident: Accident in which no one is fatally injured, but at least one casualty received serious injuries.

Serious injury/ casualty: Injury does not cause death within 30 days of the accident and either results in the casualty being detained in hospital as an in-patient, or any of the following injuries: fractures, concussion, internal injuries, crushing's, severe cuts and lacerations, severe general shock requiring treatment, or any injury which causes death more than 30 days after the accident.

Slight accident: Accident in which at least one casualty receives slight injuries but no fatal or serious injuries.

Slight injury/ casualty: Injury of a minor character such as a sprain (including whiplash neck injury), bruise or cut which are not judged to be severe or slight shock requiring roadside attention. Injuries not requiring medical treatment are included.

In addition to the above terms related to RTA, main economic terms are used in this study to label countries based on their economic status. The economic terms used in this study are taken on the basis of their definition given by WB (2012) and are stated as follows.

High-income countries: Are countries whose Gross National Income Per capita is US$ 12,616 or more.

Low-income countries: Are countries whose Gross National Income Per capita is US$ 1,035 or less.

Middle-income countries: Are countries whose Gross National Income Per capita is between US$ 1,036 to 12,615.

Mekelle City: Mekelle City in this research refers to the administrative boundary of Mekelle zone as per 2011.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

2.1.1 Definition and Concepts

2.1.1.1 Definition

Road Traffic Accident is any vehicle accident occurring in a public highway. It includes collision between vehicles and animals, vehicles and pedestrians or vehicles and stuck obstacles. Single vehicle accidents, that involve a single vehicle, which means without other road user, are also enclosed (Safecarguide 2004). In a similar manner Ajit and Ripunjoy (2004), have mentioned that Accident is an occasion, occurring abruptly, unpredictably and inadvertently under unforeseen circumstances. Seemingly, Segni (2007) have also outlined that an accident is a rare, random, multi-factor event always preceded by a situation in which one or more road users have failed to cope with the road environment. Far from the above arguments, Alister and Simon (2011) stated that accident Involves personal injury occurring on the public highway (including footways) involving at least one road vehicle or a vehicle in collision with a pedestrian and which becomes known to the police within 30 days.

In this regard, RTA can be defined as an accident that occurred on a way or street open to public traffic; resulted in one or more persons being killed or wounded, and at least one stirring vehicle was intricate. Therefore, RTA is a smash between vehicles; between vehicles and pedestrians; between vehicles and animals; or between vehicles and geographical or architectural obstacles.

2.1.1.2 Concepts

Transport is the movement of people and goods from one place to another (Peters 1982; Khanna and Justo 1986; Goodall 1987). But according to Belachew (1997), transport also comprises movement of information. Similarly, Transportation is the conveyance of people, properties and information from one place to another or it is the repositioning of people, properties and information over space.

The type of transport which exhibits accident that drastically affects the wellbeing of the people and economy of the nations is the one which involves the movement of people and or goods from one place to the other. Several RTA incidences occur throughout the world at every fraction of times in a day. Whatever the reason, where ever the scene and whoever the victim is, RTAs remain as the headache of everyone.

The manifestations of RTA are sporadic and random in space and time. Nevertheless, road safety and road incident lessening are related to many other fields of activity such as education, motorist or driver training, publicity operations, police enforcement, road traffic policing, the court system, the National Health Service and Vehicle manufacturing and engineering (Berhanu 2000). The most shocking and emerging reality of RTA is that, it will continue affecting the survival of several lives across the planet. Consequently, UN (2009), remains pessimistic in road traffic accident cases where it projected that, road traffic injuries will be the fifth – leading cause of death globally by 2030. However, WHO (2004) projected that, RTA crashes which were ranked at 9th leading cause of burden of disease by 2002 could rank at the 3rd cause of burden of disease by 2020, if the current trend in motorization continues increasing in the same or similar manner for the coming decade.

2.2 Global and Regional Trends of Road Traffic Accidents

According to WHO (2004), road traffic deaths have risen from approximately 999, 000 in 1990 to just over 1.1 million in 2002. Low-income and middle-income countries account for the majority of this increase. Although the number of road traffic injuries has continued to rise in the world as a whole, time series analysis reveals that road traffic fatalities and mortality rates show clear differences in the pattern of growth between high-income countries, on the one hand, and low-income and middle-income countries on the other. In general, since the 1960s and 1970s, there has been a decrease in the numbers and rates of fatalities in high-income countries such as Australia, Canada, Germany, the Netherlands, Sweden, the United Kingdom (UK) and the United States of America. At the same time, there has been a pronounced rise in numbers and rates in many low-income and middle-income countries.

The trends are based on a limited number of countries for which data were available throughout the period and they are therefore influenced by the largest countries in the regional samples. Such regional trends could mask national trends and the data should not be extrapolated to the national level. The regional classifications employed are similar too, but not exactly the same as those defined by The World Health Organization (WHO). There has been an overall downward trend in road traffic deaths

in high-income countries, whereas many of the low-income and middle-income countries have shown an increase since the late 1980s (WHO 2004). There are, however, some marked regional differences; Central and Eastern Europe witnessed a rapid increase in road traffic deaths during the late 1980s, the rate of increase of which has since declined. The onset of rapid increases in road traffic fatalities occurred later in Latin America and the Caribbean, from 1992 onwards. In contrast, numbers of road traffic deaths have risen steadily since the late 1980s in the Middle East and North Africa and in Asia, particularly in the former (WHO 2004).

The reductions in road traffic fatalities in high-income countries are attributed largely to the implementation of a wide range of road safety actions, including seat-belt use, vehicle crash fortification, traffic-calming interventions and traffic law enforcement. However, the reduction in the reported statistics for road traffic injury does not necessarily mean an improvement in road safety for everyone. According to the International Road Traffic and Accident Database (IRTAD), pedestrian and bicyclist fatalities have decreased more rapidly than have fatalities among vehicle occupants. In fact, between 1970 and 1999, the proportion of pedestrian and bicyclist fatalities fell from 37% to 25% of all traffic fatalities, when averaged across 28 countries that report their data to IRTAD. These reductions could, however, be due, at least in part, to a decrease in exposure rather than an improvement in safety (WHO 2004).

2.3 Causes of Road Traffic Accident

Road traffic crash results from a combination of factors related to the components of the system including roads, the setting, vehicles and road users, and the way they interact. Some factors contribute to the occurrence of a collision and are therefore part of crash causation. Other factors aggravate the effects of the collision and thus contribute to trauma severity. Some factors may not appear to be directly related to road traffic injuries. Some causes are immediate, but they may be underpinned by medium-term and long-term structural causes. Identifying the risk factors that contribute to road traffic crashes is important in identifying interventions that can reduce the risks associated with those factors (Lisa, David et al. 2005).

2.3.1 Human Related Causes of Road Traffic Accident

Human factors are without doubt the most complex and difficult to separate, as they are virtually all very momentary in nature. What existed at the time of the crash may not exist some instants later. Consider sensory capabilities, knowledge, decision making, attitude, attentiveness, fitness, health, driving skill, age, weight, strength and freedom of movement. Of these, the emotional dynamics are the greatest variable attributes and

the most difficult to ascertain. They are also subject to the most adjustment with the least remaining evidence (Lisa, David et al. 2005). Human factors in vehicle collisions include all factors related to drivers and other road users that may contribute to a crash. Examples include driver comportment, visual and auditory acuity, decision-making ability, and reaction speed. Some of the human related causes of RTA are discussed as follows.

2.3.1.1 Drink Driving

Drink driving is one of the most contributing factors to RTA occurrences in many countries of the world. For instance (WHO 2009; WHO 2010) reveals that, drink driving is responsible for between 10 and 32 % of fatal crashes.

As discussed by WHO (2004) drivers and motorcyclists with any blood alcohol content greater than zero are at higher risk of a crash than those whose blood alcohol content is zero. For the overall driving population, as the blood alcohol content escalates from zero, the risk of being involved in a crash starts to upsurge significantly at a blood alcohol content of 0.04 g/dl. Inexperienced young adults driving with a blood alcohol content of 0.05 g/dl have 2.5 times the risk of a crash compared with more experienced drivers. If a blood alcohol content limit is static at 0.10 g/dl, this will upshot in three times the risk of a crash than that at 0.05 g/dl, which is the most common perimeter in high-income countries. If the legal limit stands at 0.08 g/dl, there will still be twice the risk than at 0.05 g/dl. Alcohol ingestion by drivers puts pedestrians and riders of motorized two-wheelers at risk.

2.3.1.2 Non-Use of Seat-Belts

A significant number of lives could be saved every year by using seatbelts. Till these times many drivers are not realizing how much seat belts could save the lives of themselves and the life of their customers. What makes this fact more complex is that, although it is the worst in most of the developing countries of the world, it is a usual phenomenon in some most developed countries to see drivers with no use of seat belts while driving on public roads. WHO (2010) suggests that; In France, where the wearing rate is among the highest, it was estimated that, in 2007 if every passenger and driver had worn a seatbelt, 397 lives could have been saved (around 9% of total fatalities). Wearing a seat belt reduces the risk of a fatality by 40 – 50%. Another study by Lisa, David et al. (2005) shows that, not wearing a seatbelt is the most common cause of fatality which contributes to fatality among 63% of all vehicle occupants. In addition to this WHO (2004) have stated that Rates of seat-belt use vary greatly among different countries, depending upon the existence of laws mandating their fitting and use and the

degree to which those laws are enforced. In low-income and middle-income countries, usage rates are generally much lower. Seat-belt usage is substantially lower in fatal crashes than in normal traffic. Correctly used seat-belts reduce the risk of death in a crash by approximately 60%. In absolute similarities, supporting the above studies, WHO (2009) added that if a seatbelt was correctly used, it would reduce the risk of fatality among front seat passengers by 40-50% and among the rear seat car occupants by 25-75%.

2.3.1.3 Choice of Less Safe Forms of Travel

By one or another reason, many passengers use less safe forms of travel. It would be nothing if the passengers could arrive at their destination using any form of transportation. But several studies in different countries of the world showed that, the lesser the safety of travel is accompanied with miserable RTA occurrences. It is claimed by WHO (2004) that "Of the four main modes of travel, road travel scores by far the highest risk in most countries – using almost any measure of exposure – compared with rail, air and marine travel."

2.3.1.4 Speed

The speed of motor vehicles is at the core of the road injury problem. Speed affects to both crash jeopardy and crash magnitude. In accordance to this, recent studies have proved that as speeds increase, so do the number and severity of injuries. For instance a study reported at WHO (2004) shows that the higher the impact speed, the greater the likelihood of serious and fatal injury. The same report WHO (2004) proved that the higher the speed of a vehicle, the shorter the time a driver has to stop and escape a crash. A car moving at 50 km/h will usually require 13 meters in which to stopover, while a car moving at 40 km/h will stop in less than 8.5 meters. An average increase in speed of 1 km/h is associated with a 3% higher risk of a crash involving an injury. In severe crashes, the increased risk is even greater. In such cases, an average increase in speed of 1 km/h leads to a 5% higher risk of serious or fatal injury, travelling at 5 km/h above a road speed limit of 65 km/h results in an increase in the relative risk of being involved in a casualty crash. For car occupants in a crash with an impact speed of 80 km/h, the possibility of death is 20 times what it would have been at an impact speed of 30 km/h. Pedestrians have a 90% chance of surviving car crashes at 30 km/h or below, but less than a 50% chance of surviving impacts at 45 km/h or beyond. The likelihood of a pedestrian being killed increases by a factor of 8 as the impact speed of the car increases from 30 km/h to 50 km/h. To this end WHO (2009) summarized that, a 5% increase in average speed leads to an approximately 10% increase in crashes that cause injuries, and a 20% increase in fatal crashes.

2.3.1.5 Age of Drivers

The age of drivers affects to the behavior of their driving styles and to the level of Driver's attention. In similar sense (WHO 2004); Lisa, David et al. (2005) argued that Crash rates of male drivers aged 16–20 years were at least three times the estimated crash rate of male drivers aged 25 years and above. Teenagers are significantly more likely to be involved in a fatal crash than older drivers. At almost every blood alcohol level, the risk of crash casualty declines with increasing driver age and experience. In addition to this a study on drivers killed in road crashes estimated that teenage drivers had more than five times the risk of a crash compared with drivers aged 30 and beyond, at all levels.

2.3.1.6 Non-Use of Helmets

The use of helmets has a paramount role in reducing the severity of RTA. However, several riders in different countries of the world are enjoying their journey without using helmets until the worst effect of failing to use helmets come in to their lives. Regarding this WHO (2004); (WHO 2009; WHO 2010) dictates that Non-helmeted users of motorized two-wheelers are three times more likely to sustain head injuries in a crash compared to those wearing helmets. Helmet-wearing rates vary from faintly over zero in some low-income countries to almost 100% in places where laws on helmet use are efficiently enforced. Though helmets have generally been extensively worn in most high-income countries, there is a confirmation of a decline in practice in some countries. More than half of adult riders of motorized two-wheelers in some low-income countries do not wear their helmets appropriately secured. Child passengers rarely wear helmets, or wear adult helmets that do not effectively protect them. Helmet use does not have adverse effects on neck injuries, visibility or the ability to drive safely in traffic. Wearing a motorcycle helmet correctly can reduce the risk of death by almost 40% and the risk of severe injury by over 70% (WHO 2010).

2.3.1.7 The Use of Hand-Held Mobile Telephones

The use of mobile telephones while driving could result in unexpected RTA risks. WHO (2004) suspects that, the use of hand-held mobile telephones can adversely affect driver behavior – as regards physical as well as perceptual and decision-making tasks. The process of dialing influences a driver's ability to keep to the course on the road.

2.3.1.8 Lack of Road User Information and Campaign

Road users ought to acquire the knowledge needed to travel safely by means of formal training and their own experiences. However, inadequate knowledge of traffic regulations, traffic signs, vehicles and other elements may be some of the factors contributing to unsafe behavior and road calamities. Road user information and operations are intended to reduce accidents by promoting safer behavior in traffic, by giving road users better knowledge and more favorable attitudes towards such behavior. Another objective is increased understanding of restrictive measures which are introduced to increase safety, such as speed limits. Elvic, Runee et al. (2005) evaluated a number of studies on the effects of information campaigns on the number of accidents. They reviewed that most campaigns targeted at road accidents in general have not led to statistically significant changes in the number of accidents. On the other hand, campaigns made to specific target group such as use of seat belt, drink-driving campaign and the like have led to a decrease in number of accidents in particular types during the campaign periods.

2.3.2 Road Related Causes of Road Traffic Accident

Since the entire process of road transport is conducted on roads, the quality, size and engineering characteristics of the roads will have considerable contribution to the increase or decrease of RTA risks. WHO (2004) supports this idea by saying that, the road network has an effect on crash risk because it determines how road users perceive their environment and delivers instructions for road users, through signs and traffic panels, on what they should be doing. Many traffic management and road safety engineering measures work through their influence on human behavior. Some variables regarding the road related causes of RTA are discussed as to below.

2.3.2.1 Road Environment

Road environments have impacts on occurrences of road traffic accidents. In developed countries, there are continuous efforts to meet the safety standards of roads through safety audit during the planning, designing, and operation stage. Terje (1998) indicates that in Africa road network is mounting fast, preservation standards have started improving lately, and there is potential for improving the safety standards of the roads. However, Berhanu (2000) reports that in Ethiopia, the police have limited road and traffic engineering skill in general and thus they underestimate the contribution of roads and environments to traffic accidents and especially they lack trainings on subject area.

2.3.2.2 Roadway Characteristics

The roadway's conditions like the quality of pavements, shoulders, traffic control devices and intersections, can be a factor in a crash. Fewer traffic control devices and complex intersections with excessive signage lead to confusion. Highways must be designed for adequate sight distance for designed speed for the drivers to have sufficient perception –reaction time. The Traffic signs and signals should provide enough time for decision sight distance when the signal changes from green to red. The super-elevation on highways and especially ramps should be carefully laid with correct radius and appropriate transition zones for the vehicle to negotiate curves safely. Another important factor is the frictional force between the pavement and tires. If the tires lose contact with the pavement then the vehicle starts fishtailing.

Road factors include, but are not limited to lighting, view obstructions, signals, surface character, dimension and shielding devices. All factors are subject to adjustments by outside influences such as road surface that become slippery from rainfall. Modifying each of the listed road factors are weather, lighting, roadside devices, activities, surface deposits, damage, deterioration and age (Lisa, David et al. 2005).

2.3.2.3 Narrow Bridges

Bridges are often located on sag vertical curves where approach traffic is on down grades and a factor responsible for increasing speed which contributes to the losing control of vehicles. Bridges are also more dangerous when located on bend road sections. According to Berhanu (2000) bridges are over represented in accidents relative to the total length of the road system. Traffic accidents are also dangerous at bridges. Far-reaching review of literature on the safety effects of bridges by Berhanu (2000) points out features including bridge width, curved bridge, approach roadway alignment and adverse surface condition as the most prevalent factors of bridge accidents. Based on the findings of the cited studies, Berhanu (2000) suggests that at least the bridge shoulder should be 1.8 m wider than the approach traveled way width on rural two-lane highways (i.e. 0.9m shoulder width on each side should be carried across the bridge). Besides, frequency and severity of traffic accident at bridges can be reduced through the provision of adequate visual information to enable the driver control and navigate safely on bridges. Run-off-the-road crashes and head-on collisions are frequently associated with narrow bridges. Such crashes are related to lack of maneuvering room because of narrow lanes, shoulders and roadside hazards or curbing. Combining these factors with extreme speed might end in deadly results.

Crashes involving narrow bridges are habitually fatal. The crash rates may be lowered by increasing lane and shoulder width or completely replacing bridges.

Other study made by (TRB 1987); Ung (2007) indicates that hazards associated with bridges can be substantial. Road constriction at narrow bridges diminishes the opportunity for safe recovery by out-of –control vehicles and can result in end –of – bridge accidents. Besides, bridge approaches are often on a descending grade, a factor responsible for intensifications in speed, and, predominantly in the case of older spans, are often sharp-curved.

2.3.2.4 Road Lights

Road lights are intended to provide enough lighting for drivers to travel with comfort and safety during night periods or under low visibility conditions. This solution is commonly applied where there is the possibility of conflicts between vehicles and pedestrians or cyclists. In rural roads, the implementation of lighting on unlit roads may lead to a 64 per cent reduction in fatal accidents and 20 to 50 per cent of total accident reduction. In the other way round the absence of road lights will add up to the RTA occurrences by 20 to 50% (Sandra 2000).

2.3.3 Vehicle Related Causes of Road Traffic Accident

While vehicle design can have considerable influence on crash injuries, it must be studied in accordance to its contribution to RTA. Prior studies to this one like WHO (2004) have proved that vehicle related factors contribution to crashes, through vehicle defects, is generally around 3% in high-income countries, about 5% in Kenya and 3% in South Africa. Lisa, David et al. (2005) have argued that a small percentage of crashes are caused by mechanical failure of a vehicle, such as some form of tire failure, brake failure, or steering failure. The vehicle and roadway interaction like skid resistance play a major role in stopping the vehicle from encroaching the off road features like shoulder, median and other traffic signage. Improvements have been made in the manufacture of tires and vehicle design however defects can still occur or be the product of poor vehicle maintenance. Similarly, Ung (2007) stated that Vehicles have caused road accident because their owners did not properly maintain and regularly inspect the vehicle during the maneuver. So the road accident happened when brake failure, tire blowout, power steering failure, headlight failure. In addition to this defective or under inflated defective brakes, overloaded or poorly loaded vehicle or trailer, defective lights or indicators, defective steering or suspension and defective or missing mirrors are the major factors for the frequent occurrence of RTA.

2.3.4 Environment Related Causes of Road Traffic Accident

The climatic and environmental conditions can also be a factor in transportation crashes. Supporting this idea (Lisa, David et al. 2005); Alister and Simon (2011) argued that, Weather on roads can contribute to crashes: for example wet pavement reduces friction and flowing or standing water greater than 1/8"deep can cause the vehicle to hydroplane. Many several crashes have occurred during conditions of smoke or fog, which can reduce visibility. Vehicles travelling at high rate of speed are unable to see the slowing and or stopped vehicles in front of them which can lead in to multi – vehicle pileup. Glare can reduce driver visibility especially on east – west road way during the hours of sun rise and sun set. During foggy conditions glare off of street lights and stop lights can also affect visibility. Wind gusts can affect vehicle stability. Slippery road (due to weather), deposit on road, animal or object in carriageway, poor or defective road surface, Inadequate or masked signs or road markings are also responsible for the disaster caused by environmental characteristics to RTA.

2.4 Impacts of Road Traffic Accident

All countries in the world are currently affected by RTA. Although the effects of RTA vary from one country to the other, from nation to nation, it should be every body's concern. Some of the major impacts of RTA discussed by different organizations and scholars are conversed in the following sub-sections.

2.4.1 Economic Impact

Road traffic accidents are currently deteriorating the financial wealth of many nations. In this regard, (WHO 2004); Naci, Chislom et al. (2008) urges that, in economic terms, the cost of road crash injuries is estimated at roughly 1% of Gross National Product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries. The direct economic costs of global road crashes have been estimated at US$ 518 billion, with the costs in low-income countries – estimated at US$ 65 billion – exceeding the total annual amount received in development assistance. In addition to this, in terms of regional disparities of cost of RTA Naci, Chislom et al. (2008) indicated that, the economic cost of road crashes have been estimated to be as much as US$ 24.5 Billion in Asia, US$ 19 Billion in Latin America and Caribbean, US$ 9.9 Billion in Central and East Europe, US$ 7.4 Billion in the Middle East and US$ 3.7 Billion in Africa. When we come to Ethiopia, RTA's economic impact is even worse. As far as the economic impact of RTA in Ethiopia is concerned, Persson (2008) have discussed that, the economic impact of RTAs is substantial for Ethiopians as the annual cost is estimated to be around £40 million.

2.4.2 Social Impact

The RTA impacts are also shown with their influence on the social aspects of the livelihood. To this regard, WHO (2004) claims that, over 50% of the global mortality due to road traffic injury occurs among young adults aged between 15 and 44 years, and the rates for this age group are higher in low-income and middle-income countries. In 2002, males accounted for 73% of all road traffic deaths, with an overall rate almost three times that for females: 27.6 per 100, 000 population and 10.4 per 100, 000 population, correspondingly. Road traffic mortality rates are higher in men than in women in all regions regardless of income level, and also across all age groups. On average, males in the low-income and middle-income countries of the WHO Africa Region and the WHO Eastern Mediterranean Region have the highest road traffic injury mortality rates worldwide. The gender difference in mortality rates is probably related to both exposure and risk-taking behavior. Morbidity rates for males are considerably higher than those for females. Furthermore, about 60% of the Disability Adjusted Life Year (DALY) lost globally as a result of road traffic injury occurs among adults aged between 15 and 44 years. Seemingly, WHO (2013) stipulates that, there are large disparities in road traffic death rates between regions. The risk of dying as a result of a road traffic injury is highest in the African Region (24.1 per 100, 000 population), and lowest in the European Region (10.3 per 100, 000). Young adults aged between 15 and 44 years account for 59% of global road traffic deaths. More than three-quarters (77%) of all road traffic deaths occur among men. In an absolute similar manner Naci, Chislom et al. (2008) supports this argument by stating that, Road crashes kill and maim the most productive segments of the population; globally, in 1998, 51% of fatalities and 59% of disability-adjusted life years lost as the result of road traffic injuries occurred in the most productive age groups.

The report of WHO (2004) added that people with road traffic injuries accounted for 13-31% of all injury-related attendees and 48% of bed occupancy in surgical wards and were the most frequent users of operating theatres and intensive care units. The increased work load in radiology departments and increased demand for physiotherapy and rehabilitation services were largely attributed to road traffic injuries. Regardless of the costs of healthcare and rehabilitation, injured people bear additional costs. Permanent disability, such as paraplegia, quadriplegia, loss of eye sight or brain damage, can deprive an individual the ability to achieve even minor goals and can result in dependence on others for financial support and routine physical care. Less serious injuries can result in chronic physical pain and limit the injured person's physical activity for lengthy periods. Serious burns, contusions or lacerations can lead to emotional trauma associated with permanent disfigurement.

WHO (2009) states that, over 90% of the world's fatalities on the roads occur in low and middle income countries, although these countries only have about 48% of the world's registered vehicles. The WHO anticipates, unless immediate action is taken, that over the next 15 years, the number of people dying annually in the road traffic crashes may rise to 2.4 million. This report also urges that, given these numbers, road traffic injuries have to be seen in low and middle income countries as one of the most important health problems along with diseases such diarrhea, malaria, HIV/AIDS and tuberculosis.

2.5 Black Spots of Road Traffic Accident

2.5.1 Black Spot Definition

Black spot areas in RTA are defined in different ways by different scholars. From the perspective of Rokytova (2000) black spots are defined as locations that are generally classified after an assessment of the level of risk and the likelihood of a crash occurring at a location. Black spot safety work can be designated as the task of improving road safety through variations of the geometrical and environmental characteristics of the problematic sites in the existing road network. In towns and cities, there is a tendency for traffic accidents to cluster at specific places, often at intersections. A concentration of accidents at a specific spot may partly be due to inappropriate road design or inappropriate traffic control at that place. In such cases, the clustering of accidents can be avoided or reduced by improving road design or traffic control.

In another words, accident black spot on a National Highway in Norway is defined as any place with a maximum length of 100 meters, where at least four injury accidents have been testified to the police in a four year period (Elvic, Runee et al. 2005). Thus, a black spot in the UK may well have only five injury accidents in three years, whereas a city in Bangladesh may have black spot defined as having more than 10 injury accidents in a year (Geurts and Wets 2003). In most developed states, black spots are defined as the locations where there are 12 accidents in 3 years per 0.3 kilometers (Guo, Gao et al. 2003). In Czech Republic, the black spot criterion is that junctions or 250m long road sections that are considered as black spots on condition that at least 3 road accidents with injuries occurred within 1 year or at least 3 road accidents with injuries of the same type occurred within 3 years or at least 5 road accidents of the same type occurred within 1 year (Rokytova 2000). Study on single carriage way trunk road Walmsley, Summersgill et al. (1998) revealed that the criterion used to delineate road sections for accident analysis are age of opening, carriageway width, curbs, hard strips, and speed of the road section.

Elvic, Runee et al. (2005) points out black spots on national highways in Norway have heavy traffic but do not have particularly high accident rates when compared with places which are not classified as accident black spots. Ranking of black-spots were done with various alternatives. Jonnessen and Sakshaug (2006) show three alternative methods of ranking black spots. These are number of accident with personal injury or serious personal injury, accident rates (accident per million vehicle kilometer) and potential for accident reduction. In addition to this, Lisa, David et al. (2005) stated that Black spot areas are sites that have had more than one fatal crash, sites with multiple crashes within a mile from one another.

2.5.2 Black Spot Analysis

Road crash black spot analysis has been widely examined in the academic press, and various types of methods for identifying unsafe locations have been developed. Simple methods for identifying unsafe locations, where the number of crashes or the crash rate per unit exposure exceeds a given threshold, are routine and straightforward (Taylor, Bonsall et al. 2000). Austroads (1988) describes another method that uses critical crash rates to determine whether the crash record of each location is significantly greater than the system wide average. Another statistical models, such as the empirical Bayes method, include developing a statistical model based on the reference population and comparing the expected number of crashes with the observed number (Elvic and Runee 2008; Li and Zhang 2008). Not only crash rates, but unsafe locations can be ranked according to their severity. Geurts, Wets et al. (2004) use the values of 1, 3, and 5 as the weights for a light, serious, or fatal casualty of a crash. Likewise, ranking methods also are made of a severity index, which is computed based on weights of 3.0 for fatal crashes, 1.8 for serious injury, 1.3 for other injury, and 1.0 for property damage only crashes (RoTA 1994). In addition to these individual ranking methods, other composite methods that consider more than one factor at a time are also used. For instance, Vasudevan, Pulugurtha et al. (2007) use the average of the ranks according to frequency, weighted factor, pedestrian exposure, and traffic volume for ranking pedestrian hazardous locations. However, these methods, along with other traditional methods, focus on road segments or specific locations and thus produce results that are partially dependent on the length of road segment (Thomas 1996) and might not be able to capture area wide crash hot spots (Anderson 2009).

Various methods for studying spatial patterns of crash data as point events have recently been developed. One of the most widely used is Kernel Density Estimation (KDE). Many recent studies use planar KDE for hot spot analysis, such as the study of high pedestrian crash zones (Vasudevan, Pulugurtha et al. 2007) road crash hot spots

(Anderson 2009), and highway crash hot spots (Erdogan 2009). The goal of planar KDE is to develop a continuous surface of density estimates of discrete events such as road crashes by summing the number of events within a search bandwidth. However, planar KDE has been challenged in relation to the fact that road crashes usually happen on the roads and inside road networks that are portions of two-dimensional space. Road crashes are, therefore, needed to be considered in a network space, a simplification of the road network represented by one-dimensional lines. Numerous studies have extended the KDE to network spaces, which estimates the density over a distance unit instead of an area unit (Yamada and Thill 2004; Xie and Yan 2008). Neither planar or network KDE can be tested for statistical significance; this is a major weakness of these methods (Xie and Yan 2008; Anderson 2009).

2.6 Road Traffic Accident in Ethiopia

Most of the road deaths in developing countries involve vulnerable road users such as pedestrians and cyclists. In Ethiopia, pedestrian injuries account for 84% of all road traffic fatalities compared with 32% in Britain and 15% in the United States of America. In contrary, in the heavily motorized countries, drivers and passengers account for the majority of road deaths involving children (Bunn, Collier et al. 2003). Similarly, Mekonnen (2007) quoted that, RTA in Ethiopia is a serious problem. The RTA death rate is estimated to be 130 per 10,000 vehicles. Of the total victims of RTA who lost their lives, over half are pedestrians, out of whom 30% are children. In Ethiopia, one among five people injured dies due to RTA. Based on a five-year average records, of the personal injury accidents, 81% are caused due to drivers error, 5% due to vehicle defect, 4% due to pedestrian error, 1% due to road defects and 9% due to other problems in Ethiopia. Studies further shows that the professional drivers are involved in 88% of the fatal accidents. Special purpose vehicles and motor bicycles cause 8% of such accidents. On the other hand, automobile drivers have very good safety records with only 4% of the fatal accidents, which is equivalent to a rate of 12 fatal accidents per 10,000 vehicles.

Conferring the National Road Safety Coordination Office of Ethiopia, the main underlying reasons for the frequent RTA occurrences and severe impacts of RTA in Ethiopia are Improper behavior or lower skill of drivers, Poor vehicle technical conditions, Animals and carts using the highways, Pedestrians not taking proper precautions, Poor traffic law enforcement, Poor emergency medical services and Insufficient safety considerations given in road development.

In addition to this Segni (2007) added another responsible reasons of RTA occurrences in Ethiopia like driving without respecting right-hand rule, failure to give way for vehicles and pedestrians, overtaking in snaky horizontal curves, following too close to the vehicle in front, improper turning and speeding. These causes contribute to 73% of the total accident in the year 2004/05 in Ethiopia but the other possible reasons accounted for less than 27%.

It would be impossible to attach a value to each case of human sacrifice and anguish, add up the values and result a figure that captures the national social cost of road crashes and wounds. Conversely, the economic expenses of road traffic accidents are, obviously, a heavy burden for the national economy. In addition to this UN (2009) added that the economic costs of road crashes and injuries are estimated to be 1% of Gross Domestic Product (GDP) in low-income countries such as Ethiopia.

In another stance , Mohammed (2011) Put his findings of the cost of RTA in Ethiopia on the basis of the Ethiopia's data and economic figure of 2009/10, as the cost of damage only, slight, serious and fatal road traffic crashes were 327.12 million, 204.65 million, 619.38 million, and 716.02 million ETB respectively. This represents the total national economic loss resulting from road accidents to be estimated as ETB 1.867 Billion which is equivalent to 145.07 million United States Dollar (USD) considering the exchange rate of the same year, or approximately 0.49% of the GDP of the country in the same year. Another study conducted by Ethiopian Roads Authority stated that, RTA costs Ethiopian economy between 350 - 430 million Birr annually, and loses almost 1860 lives each year with another 8,690 people reported injured (CSA 2007).

2.6.1 Road Traffic Accident Reporting System in Ethiopia

As stated by UN (2009), similar to most countries of the world, police is responsible for traffic accident investigation and reporting in Ethiopia. According to the Ethiopian transport regulation (*Negarit Gazeta,* 1963, which is still in use with amendments), a driver of a vehicle involved in a road accident shall notify the nearest police station immediately if the accident involves personal injury and within twenty-four hours if it involves property damage only. According to the regulation, all accidents are reportable. In practice, however, the police are notified only when the accident involves serious injury, agreement cannot be reached between parties involved or if police accident report is required for insurance. Because of this, the reporting of nonfatal accidents is uncertain. Thus, the under-reporting of road accidents in Ethiopia is expected to be quite considerable.

Normally, in response to notification of an accident, a traffic police investigator attends the scene of the accident. Based on the information obtained from observations, the parties involved in the accident, and other evidences, police prepares a factual report and makes the sketch of the site on a plain sheet of paper. The police, who are inadequately equipped and trained, understandably, primarily see their role to take action if the law has been broken and give much attention to get evidence for prosecution rather than to investigate the many factors involved in the accident.

On return from the accident site, an account of the accident is recorded in a daily report book at a local police station or traffic office. The accident recordings in the daily recording book form the basis of the Ethiopian road accident statistics. Periodic summaries of aggregate road accident records are made and sent to the immediate higher police department. They finally reach the Federal Police where the national road accident statistics are compiled.

The content of the road accident reporting, as it exists now, misses relevant details of an accident report required for any road safety improvement works. The reporting form, in the daily report book, is not designed to include details of each vehicle and road user involved in an accident. The report, further, does not contain details of the road section and precise location of an accident. The location of an accident is usually reported broadly by "*Kebelle and Wereda*" or the name of the surroundings. Besides, because a plain paper is used on the spot, the investigating policeman is unlikely to remember the required accident details and as a result the form available at the local traffic police office is never completely filled.

The information recorded could generally be adequate for the police work, but it is of limited use to other bodies requiring information for identifying the causes and appropriate remedial measures. It is primarily inadequate in determining the location of accidents and the factors involved. Moreover, accident reporting lacks a significant level of consistency. Terminology of accident details does not have a uniform definition even among the staff members at a police station. There also exists a significant variation in accident reporting in different regional states.

In addition to the indicated limitations of accident reporting, there is no established system of computerized accident data bank to store detailed information on individual road traffic accidents occurring in the country. This is another handicap for the efficient management of the reported traffic accident data. Moreover, there is no system of periodic road traffic accident analysis and dissemination system to give information on road traffic accident trends, specific accident problems so that stakeholders are aware and aim to improve the situation.

The accident statistics, although not complete and with all sorts of limitations, can, however, be used by interested stakeholders to make a broad accident analysis for various purposes. Moreover, the existing data can be used to create awareness and define policy and mobilize human and financial resources towards alleviating the problem.

CHAPTER THREE

3. DESCRIPTION OF THE STUDY AREA

3.1 Background of the Study Area

3.1.1 Location and Administrative Setup

Mekelle is a city found in the Northern part of Ethiopia and is serving as the capital of Tigray Regional State. Mekelle is one of the seven zones of Tigray Region. It is located some 783 kilometers North of the capital Addis Ababa, at $13^0 26'$ to $13^0 36'$ North latitudes and $39^0 25'$ to $39^0 33'$ East longitudes with an average elevation of 2084 meters above mean sea level. The total area of the city by the year 2011 was about 135.21 km^2. Its municipality is believed to have been established in the early 1940s. Administratively, Mekelle is divided into seven sub – cities namely Kedamay Weyane sub- city, Adihaki sub-city, Ayder sub- city, Hadinet sub-city and its extension, Hawelti sub-city, Quiha sub-city and Semen sub-city and its extension (MAO 2010).

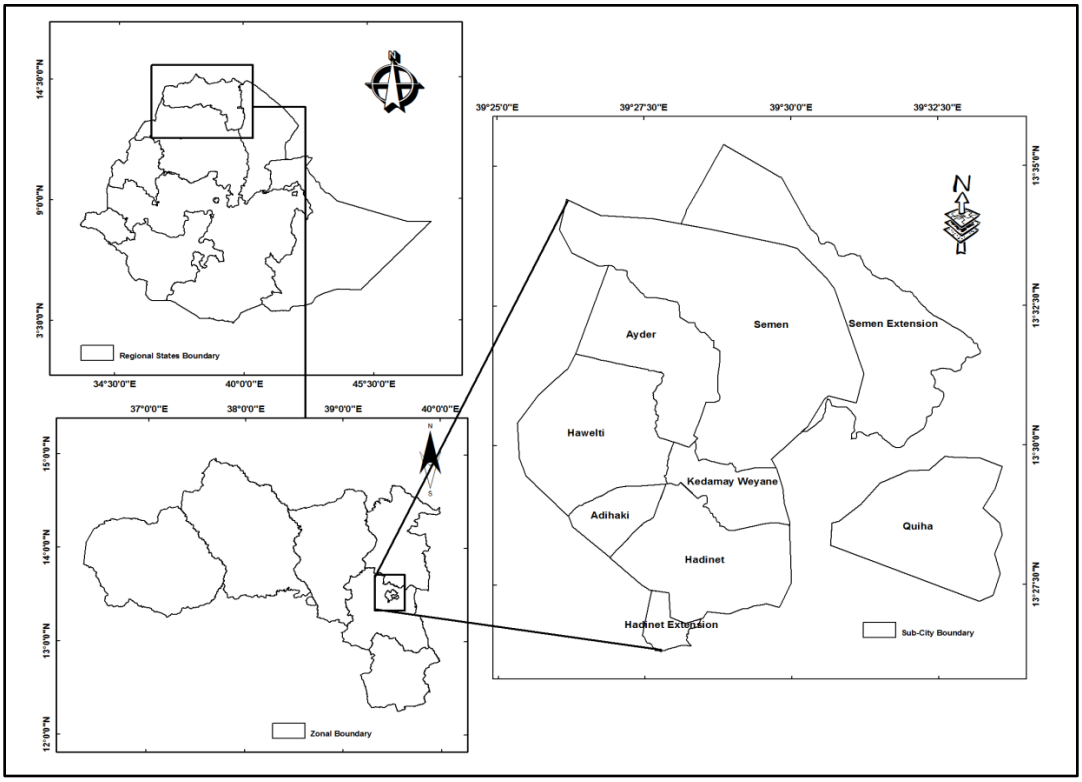


Figure 1: Mekelle City (Study Area)

3.1.2 Demographic Characteristics

Based on the Census conducted by the Central Statistical Agency of Ethiopia CSA (2007), Mekelle City had a total population of 215,914 of whom 104,925 were men and 110,989 women. In addition to this, Assefa (2012) have stated that the total population of the city have reached 254, 689 by 2011. Moreover, According to CSA (2013) the population projection figures of Mekelle City in June 2013 as projected based on the results of the May 2007 National Population and Housing Census of Ethiopia indicates that the total population of the city was expected to reach 286, 505 out of whom Male population comprises 139,183 and Female population 147,322.

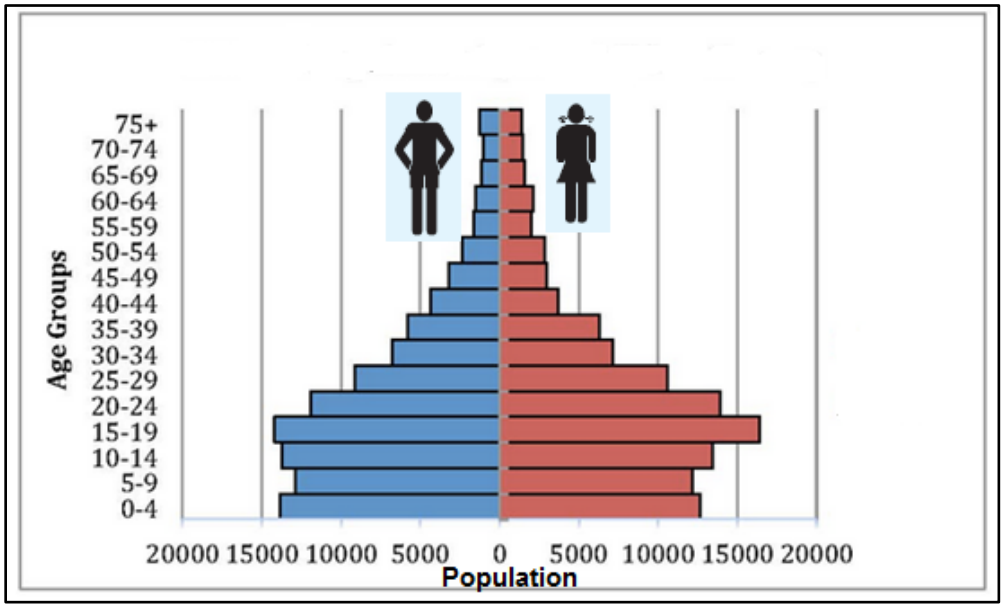


Figure 2: Mekelle City Population Pyramid (CSA 2007)

As shown in figure 2; the population pyramid of the city is broad at its base and narrow at its apex. This phenomenon implies that the population of the city is characterized by high fertility rates. In addition to this the old aged population of the city takes the smaller share of the entire population mainly due to higher mortality rates and shorter life expectancy.

3.1.3 Topography

3.1.3.1 Slope

Slope shows the upward or downward inclination of a natural or artificial surface. It is a deviation of the surface from the horizontal. The surface of Mekelle City exhibits varied slope characteristics. As shown in figure 3, according to the slope classification criteria set by FAO (2006), 45.09km^2 (34%) of the total surface of the city is gently sloping and 37.95km^2 (29%) of the city's total surface area is sloping type. In addition to this, 8 .8km^2 or (7%), 20.6km^2 or (16%), 13.9km^2 or (11%), 4km^2 or (3%) and 1.2km^2 or (1%) of the surface of the city is level, very gently sloping, strongly sloping, moderate steep and very steep respectively.

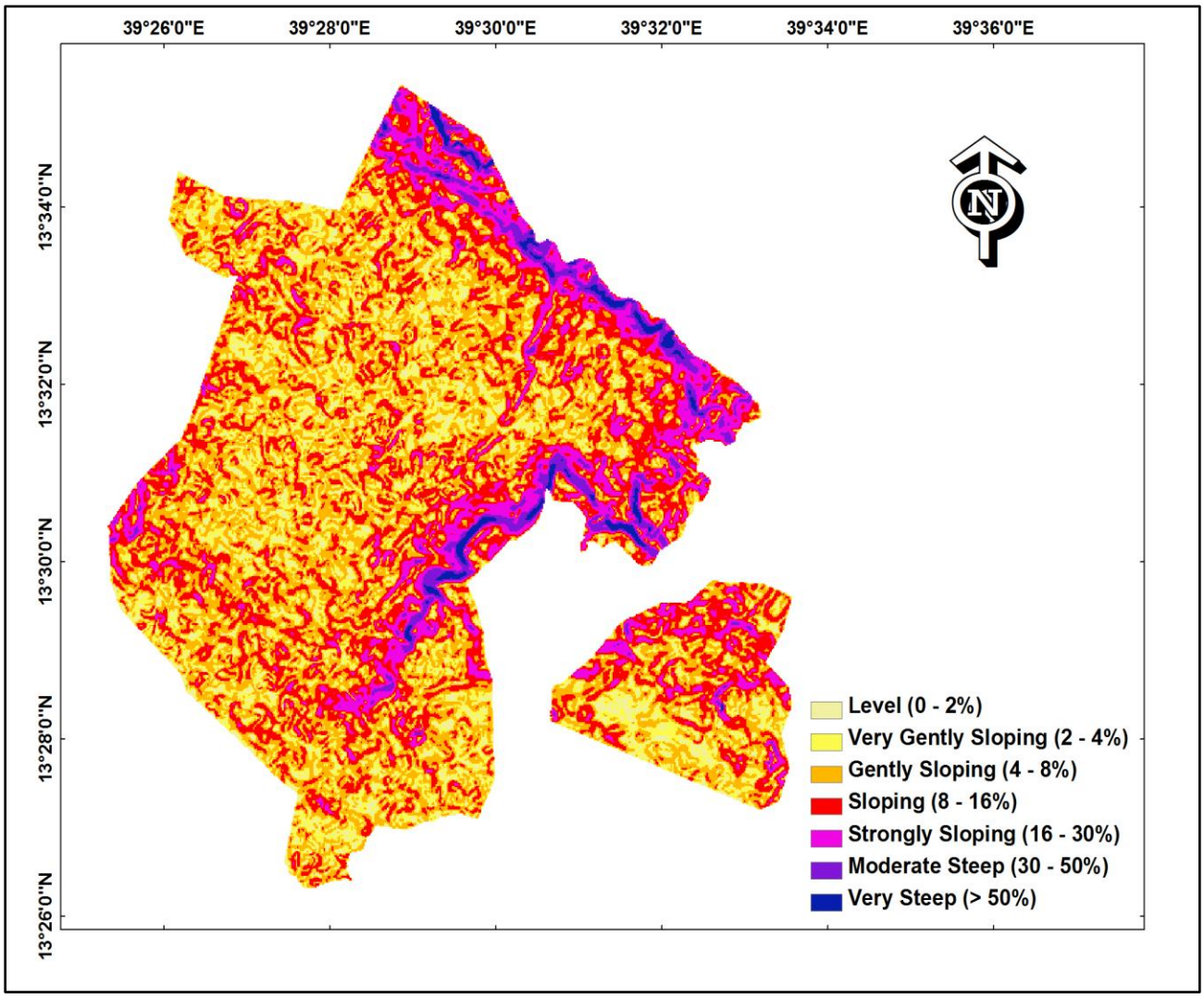


Figure 3: Slope Map of Mekelle City

3.1.3.2 Aspect

Aspect identifies the slope direction or the compass direction a hill faces. As portrayed in figure 4, 20.64km^2 or (16%) and 19.35km^2 or (15%) of the total surface of the city faces to the south west and west direction respectively. In addition to this, 14%, 12% and 11% of the surface of the city is inclined towards north west, north east and southern direction.

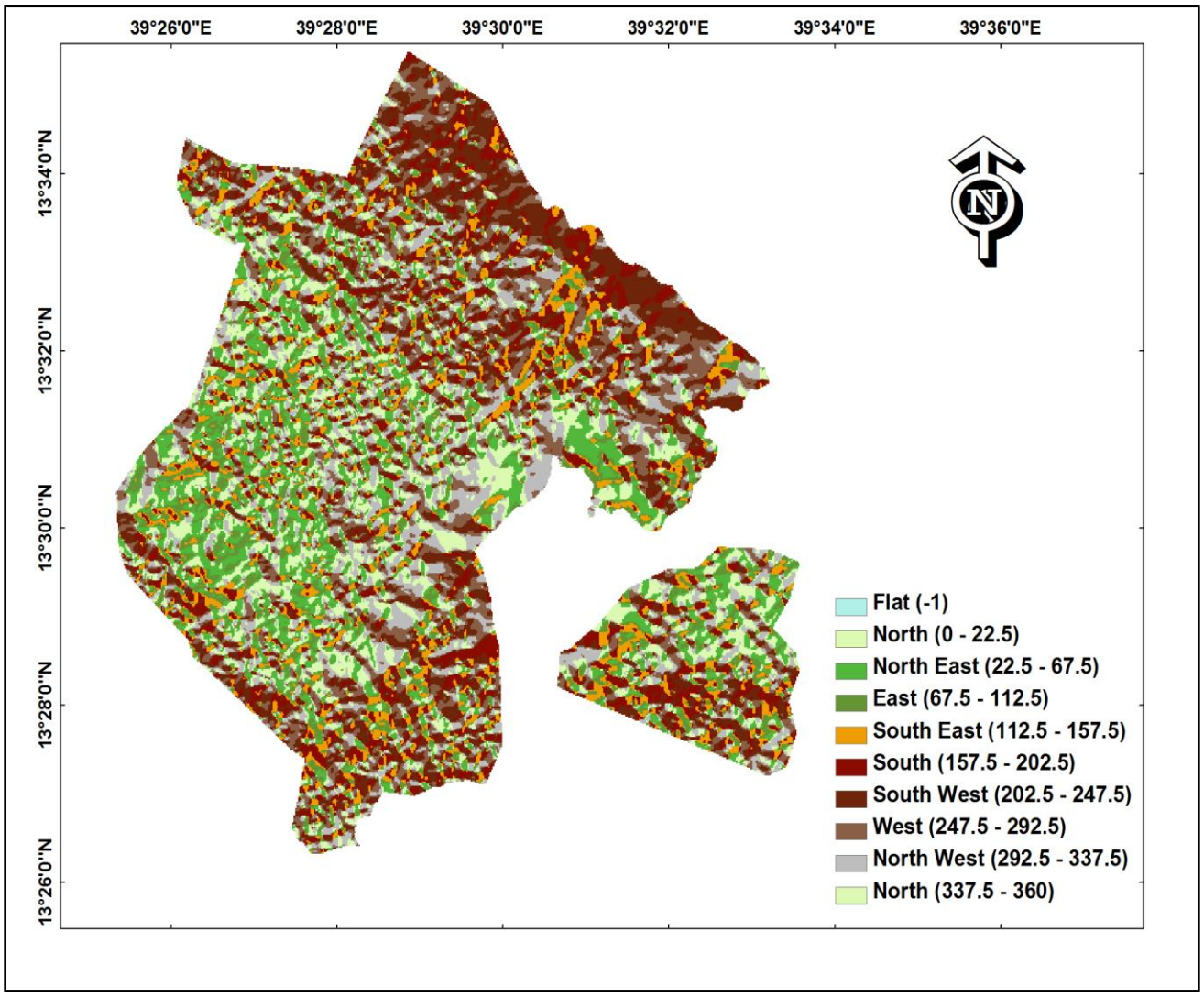


Figure 4: Aspect Map of Mekelle City

3.1.4 Climate

3.1.4.1 Precipitation

Mekelle City exhibits distinct rainy and dry seasons. The average annual rainfall of the city reaches 663 mm (Figure 5). The City gets its maximum amount of rainfall during the summer season (June, July and August). Moreover, Mekelle City gets 74.69% of its total annual rainfall during the summer season. In contrary, the minimum amount of rainfall in the city is observed in the winter season (December, January and February). Likewise, August is the wettest while December is the driest months of Mekelle City.

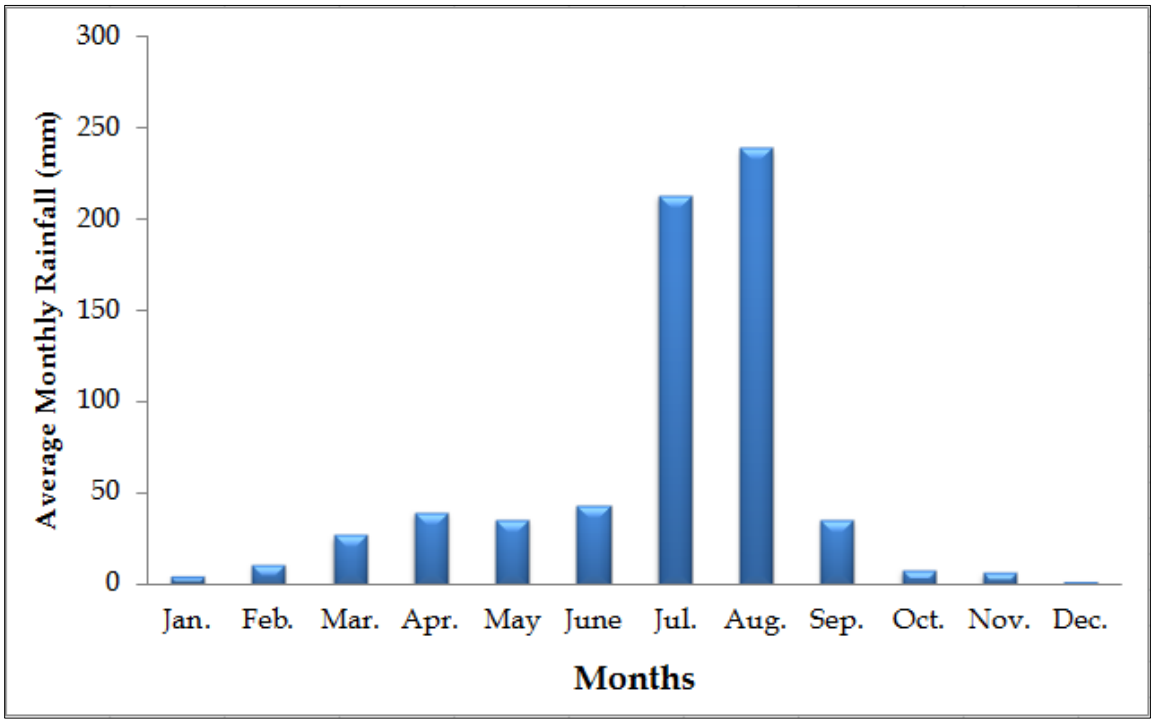
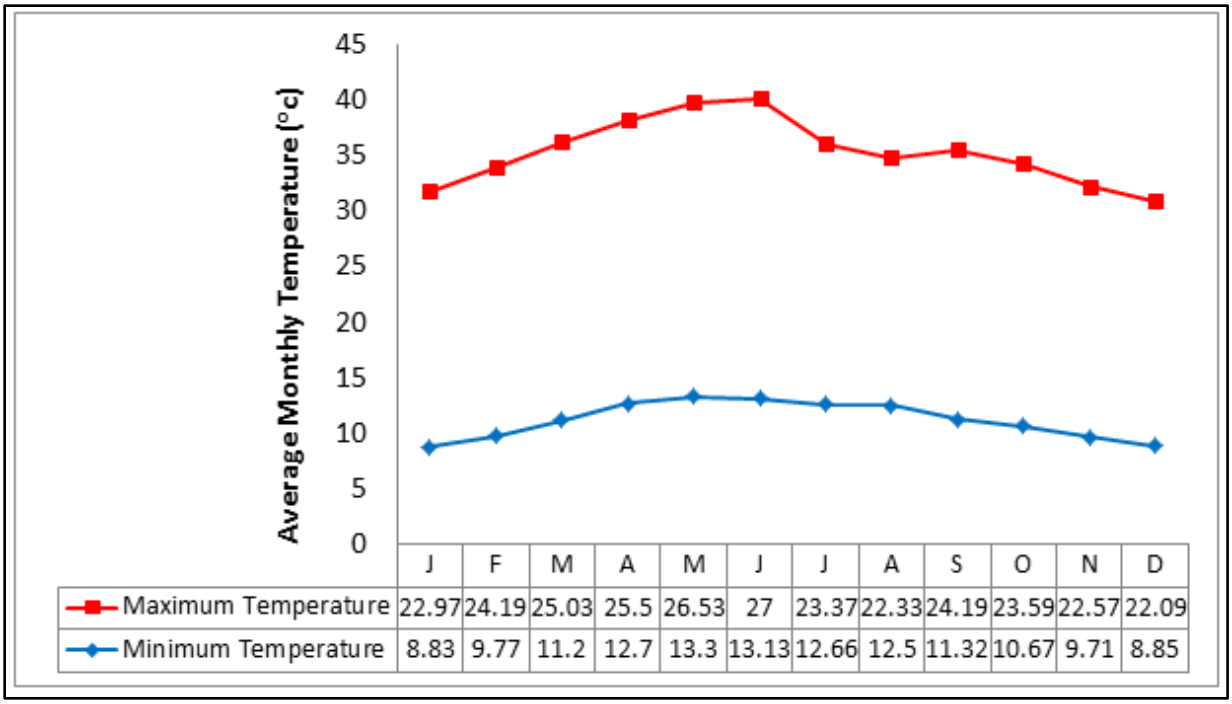


Figure 5: Average Monthly Rainfall of Mekelle City (NMA 2009)

3.1.4.2 Temperature

The overall average monthly minimum and average monthly maximum temperature of Mekelle City reaches 11.33 ^{o}c and 24.16 ^{o}c respectively (Figure 6). Therefore, the average annual temperature of the city is 17.75^{o}c and its annual range of temperature is 4.5^{o}c. Besides, winter season (December, January and February) is the coldest while spring season (March, April and May) is the warmest in the city. More specifically, the highest and the lowest temperatures in the city are recorded during May and December respectively.



	J	F	M	A	M	J	J	A	S	O	N	D
Maximum Temperature	22.97	24.19	25.03	25.5	26.53	27	23.37	22.33	24.19	23.59	22.57	22.09
Minimum Temperature	8.83	9.77	11.2	12.7	13.3	13.13	12.66	12.5	11.32	10.67	9.71	8.85

Figure 6: Average Monthly Maximum and Minimum Temperature of Mekelle City (NMA 2009)

3.1.5 Road Network Infrastructure

Mekelle City like many other cities in Ethiopia has an urban transportation infrastructure that was initially designed for largely non-motorized travel. However, the quality, length and purpose of roads in the city have shown a significant progress with time. As shown in table 1, in 2011, the city had a total length of 307.315km out of which 190.858km (62.1%) is gravel road and 60.6km (19.7%) is covered with the emerging and widely spread type of road pavement in the city; cobblestone. In addition to this, 55.317km (18%) is asphalt road and the remaining 0.54km (0.2%) is concrete type of road. Regarding the road infrastructures, a total of 159.85km of the city was covered by street lights in 2011. The total length of side walkways in the city reaches 32.66 km of which the 31.9km is made of stone pavement and the rest concrete. There are also about 22 bridges of different size and quality found in the city.

Table 1: Road Type and length in Mekelle City (2008-2011)

Road Type	Years				
	2008	2009	2010	2011	%
Asphalt Roads	45 km	45 km	54.6 km	55.317 km	18.0
Concrete Roads	0.54 km	0.54 km	0.54 km	0.54 km	0.2
Cobblestone Roads	7.5 km	14.5 km	23 km	60.6 km	19.7
Gravel Roads	108 km	114 km	152 km	190.858 km	62.1
Total	161.04 km	174.04 km	230.14 km	307.315 km	100.0

Source: Construction and Design Office of Mekelle City (2011)

CHAPTER FOUR

4. MATERIALS AND METHODS

4.1 Nature and Source of Data

Qualitative and quantitative data were collected from both primary and secondary sources. The primary data were obtained by the means of locating the Traffic accident spots of the city using *'Add Placemark'* tool in Google Earth and through interviews made with key informants form Tigray Region Police Commission and Mekelle City Traffic Office officers. In addition to this, the secondary data (hard copy) were collected from the daily RTA recording file of Mekelle City Traffic office, Construction and design office of Mekelle City, Tigray Region Police Commission, Tigray Region Bureau of Finance and Economic Development. The summary of types and sources of data which were used in this study are shown in Table 2.

Table 2: Nature and source of data

S.N	Data	Data Type	Data Source
1	RTA data of Mekelle City	Secondary	Mekelle City Traffic Office
2	RTA data of Tigray Region	Secondary	Tigray Region Police Commission, Tigray Region Bureau of Finance and Economic Development
3	Location of RTA Spots	Primary	Google Earth
4	Vehicle related data	Secondary	Mekelle City Road Transport and Construction Office
5	Road type, quality and road infrastructure	Secondary	Construction and Design Office of Mekelle City
6	Additional Information of RTAs in Mekelle City	Primary	Interviewee Traffic Officers
7	Mekelle City ASTER DEM	Secondary	https://reverb.echo.nasa.gov

4.2 Data Collection Methods and Procedure

The RTA data of Mekelle City from 2008 to 2011 were collected from the daily RTA records file of Mekelle City Traffic Office. Data collection format was prepared in excel document format which enables us to collect, filter and edit the required variables for the study. The main RTA input data sets collected from the daily RTA records file of Mekelle City Traffic Office includes the following variables.

- Accident date
- Accident month
- Accident place or accident location
- Accident reason
- Accident time in military time format
- Accident type
- Accident year
- Driver – vehicle relation
- Driver's age in years
- Driver's driving experience in years
- Driver's sex
- Estimated accident cost in ETB
- Road divide type
- Road pavement
- Road moisture in the time of accident
- Vehicle service age in years
- Vehicle type
- Weather condition in the time of accident

The service year of vehicles is determined using vehicles model and using the time the vehicles registered in the road transport office. The price of property damages is estimated by technical professionals and insurance companies in reference to the price of damaged properties in the time of the accident.

In order to ease the analysis of the data and to locate the RTA Spots in Google Earth, all RTA Spots of the city were assigned with a special code. Following the data filter, editing and data coding procedures, four years RTA database of the city was made in an Excel format. The data base consists of the RTA records of 1275 RTA incidences of Mekelle City from 2008 to 2011. The locations of known RTA Spots of the city in the last four years were collected from the Google Earth through *'Add Placemark'* tool using the special code given to the RTA spots.

4.3 Data Preparation

After adding the location of RTA places in Google Earth as point data, it was converted in to shape file using ArcGIS 9 software by uploading via DNRGPS 6.0.0.8 Application software. The four years RTA data which was arranged in Excel format was again filtered and rearranged using Pivot table for further application and was saved as CSV (comma delimited) (*.csv) format. After this procedure, the total RTA data was linked to the aforementioned shape file in to the ArcMap using the *'Joins and relates'* function. The *'clip'* function from the *'Analysis tools'* was manipulated to pin sub-cities from Mekelle City administration map shape file so as to know the number of RTA Spots included in each sub-city in each year. Using input data like RTA Spot special codes, RTA Spot code count, RTA Spot name, RTA year and Mekelle sub-city boundary shape file; spatial RTA point maps of RTA Spots and RTA Black spots of each year and spatio-temporal RTA Black Spot maps were prepared for analysis.

4.4 Data Processing, Presentation and Analysis

The RTA Data collected from Mekelle City Traffic Office were processed using descriptive statistics like crosstabs, frequencies, averages, totals and percentages in the Statistical Package for the Social Sciences (SPSS) version 19 software. Accordingly, the data was organized and presented in the form of tables, pie charts, column bar charts and line graphs. The difference and trend in the frequency of RTAs was presented on maps using graduated symbols and bar charts.

Analysis of the data was basically made in five sections. The first part tried to analyze the general characteristics of RTAs in Mekelle City using the collected 1275 RTA incidences of the city in the last four years. The second part conversed about the spatio-temporal variation and distribution of RTAs across the city in general and amongst the sub-cities in particular. Spatio-temporal maps of RTA Spots and RTA Black Spots of Mekelle City were generated using the spatially referenced 1161 known places for RTA incidences out of the total 1275. This is because the name of the places of the remaining 114 RTA incidences of the city of the last four years was not specified in the daily RTA records of Mekelle City Traffic Office. The third part discussed about the trend of occurrence of RTAs in the whole city in general and in the RTA Black Spots in particular. The fourth part specified the major causes and the last about socio-economic impacts of RTA in Mekelle City. The RTA data of Mekelle City from 2003 to 2007 was also used so as to analyze the frequency, trend and socio-economic impact of road crashes comparing to the RTA occurrences in the city between 2008 and 2011. The information gathered from the key informants was analyzed in line with each associated characteristics of RTA of the city.

4.5 Road Traffic Accident Black Spot Identification

Road Traffic Accidents Spot/s is/are place/s where even a single RTA has occurred regardless of its frequency or severity level of its consequence. However, as explained in the prior chapters, the definition of Black spots remains subjective among different scholars and different countries. For instance, Rokytova (2000) have stated that, black spots are generally classified after an assessment of the level of risk and the likelihood of a crash occurring at a location is made. In another stance, Lisa, David et al. (2005) argued that, black spot areas are sites that have had more than one fatal crash, sites with multiple crashes within a mile from one another. In addition to this Elvic, Runee et al. (2005) stated that in UK, Black spots are places where only five injury accidents occur in three years. In contrary, Geurts and Wets (2003) explained, from the perspective of Bangladesh, black spots are areas that exhibit more than 10 injury accidents in a year. Elvic, Runee et al. (2005) added, other developed countries like Norway considers black spots as any place with a maximum length of 100 meters, where at least four injury accidents have been reported to the police during a four year period. The above varied definitions of black spots have dictated that, a place to be considered as a black spot should exhibit fatal crash, multiple crash or injury in a defined time and space. Space, time and frequency of RTA occurrences are however considered as major criteria to identify RTA black spots in Mekelle City in this research. Thus, we defined here RTA black spot as a single place that exhibits five or more RTA occurrences in one year. In addition to this, any place which exhibited only one or more RTA scene in the whole study period is hereby considered as RTA Spot. This implies that, all RTA Black Spots are RTA Spots but all RTA Spots may not necessarily be RTA Black Spots. Top 10 RTA Black Spots and consistent RTA Black Spots were identified based on their total RTA Frequency and consistency as RTA Black Spot in the whole study period respectively.

Out of 1275 RTAs occurred in Mekelle City in the last four years, 1161 of them are tied with their spatial reference. Based on their spatial distribution, 247 different RTA spots where these 1161 RTAs have occurred from 2008 to 20011 are identified. Since the daily record of RTA occurrences in the city is not consistent and sometimes left incomplete, the location of the remaining 114 RTA scenes were not located. Accordingly, the spatio-temporal distribution assessment of RTAs in the city relies on the available 1161 RTA data. RTA Spots like May Shibti, Northern command and Gergembez which are found between Hadinet and Quiha sub-cities are considered as RTA Spots of Quiha sub-city in this study. Semen extension and Hadinet extensions are also considered as parts of Semen and Hadinet sub-cities respectively. The location of RTA Spots and RTA Black Spots is shown using their respective codes in all maps of this study. The RTA Spot's code and corresponding name of the RTA Spots is shown in Appendix 1.

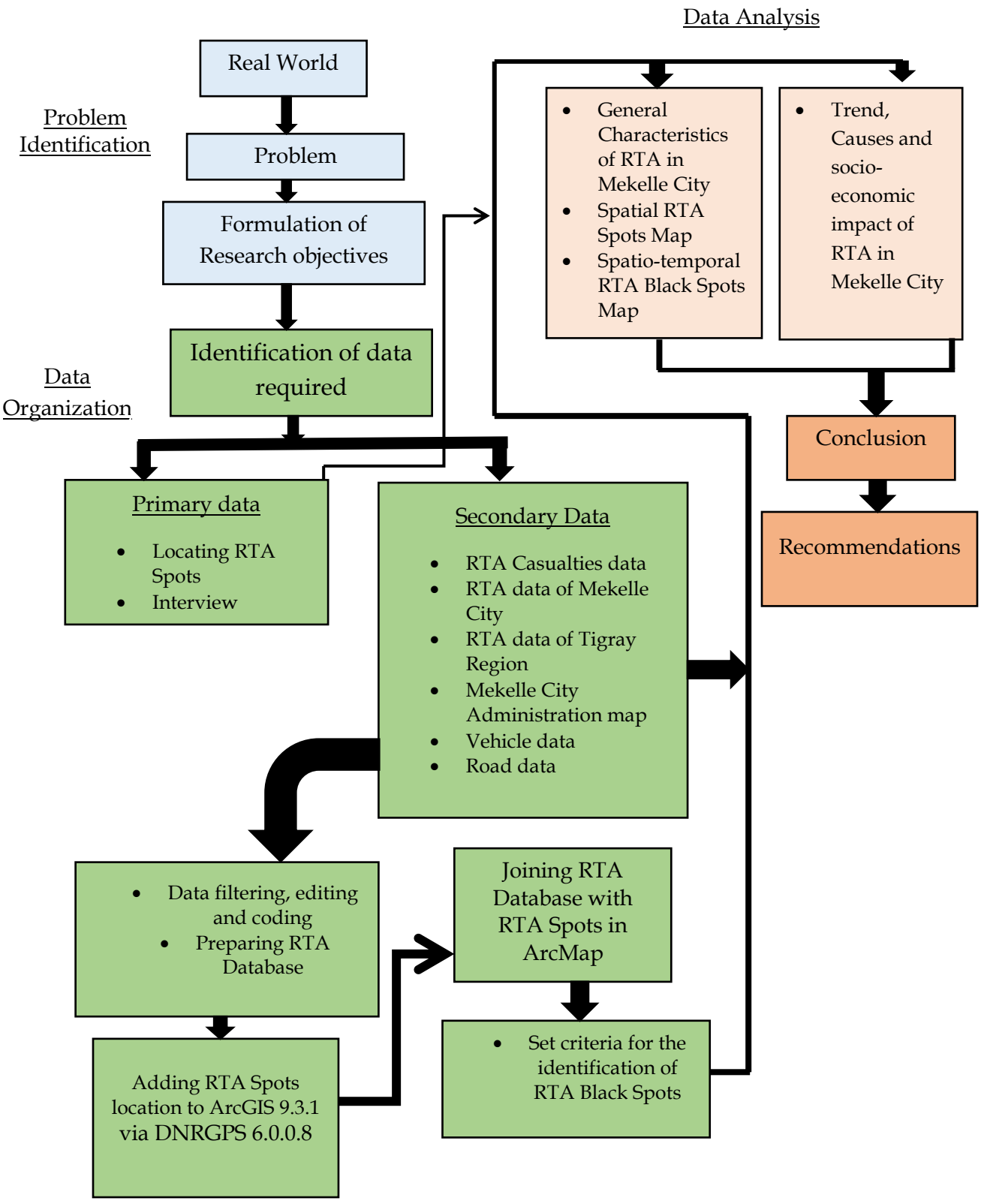


Figure 7: Research Design

CHAPTER FIVE

5. RESULT AND DISCUSSION

5. 1 General Characteristics of Road Traffic Accident in Mekelle City

5.1.1 Time and Road Traffic Accidents

5.1.1.1 Temporal Variation of Road Traffic Accidents

The occurrence of RTA can vary within the 24 hours of a day. As discussed in the previous chapters, the environmental factors like the availability of light, the volume of vehicles, the number of pedestrians and the like have a greater impact in the variation of RTA distribution with in a day. Table 3 specifies the alteration of distribution of RTA occurrences in Mekelle City in terms of the variation of time.

Table 3: Temporal variation of RTAs by hours of a day in Mekelle City (2008-2011)

Time interval (Military time format)	Accident year				Total	%
	2008	2009	2010	2011		
12 am – 6 am	27	24	27	21	99	7.8
6 am – 12 pm	103	146	86	70	405	31.8
12 pm – 6 pm	92	109	139	163	503	39.5
6 pm – 12 am	48	49	66	65	228	17.9
Missing	18	14	4	4	40	3.1
Total	288	342	322	323	1275	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

The variation in the hours of a day exhibits the difference in RTA occurrences in Mekelle City (Table 3). The time between 12 pm to 6 pm reveals the largest proportion (39.5%) of all the RTA scenes in Mekelle City between the years 2008 to 2011. 503 (39.5) accident records were observed in this time interval. The frequency of occurrence of RTAs in this time segment even exhibited a continuous increase from the years 2008 to 2011. Ironically, the time between 12 am to 6 am contributes only for 99 (7.8%) of RTA records in the city with in the study time. In nearly similar context, Segni (2007) have discussed that the time between 3 pm to 6 pm contributes for the majority of RTA occurrences in the roads found between Addis Ababa and Shashemene. Generally,

RTAs in Mekelle City are frequently observed in the day time than in the night time between 6 am to 6 pm. About 908 (71.21%) of all the accidents recorded in the study period have been observed in the day time. The rest 327 (25.64%) RTA incidences have been recorded in the night time between 6 pm to 6 am. This means, driving or travelling on the roads of Mekelle City between 12 pm to 6 pm is five times more precarious for being engaged in RTAs than driving or travelling between 12 am to 6 am. This phenomenon is evident mainly due to the fact that the movement and volume of vehicles and pedestrians is more in the day time than in the night time. This result is different from Bahir Dar City. Addis (2003) stated that about 51% RTAs in Bahir Dar City are commonly exhibit during the day time as opposed to 49% in the night time. The difference in the temporal occurrence of RTAs between day and night times in Mekelle City also disproves the idea stated by Hoobs (1979) that, night time accident rates are about 50% greater than daytime accidents.

5.1.1.2 Monthly Temporal Variation of Road Traffic Accidents

Like the variation in the distribution of RTAs within the 24 hours of a day, there is disparity of RTA frequencies between the different months of a year.

Table 4: Temporal variation of RTAs in a year by month in Mekelle City (2008-2011)

Months	Accident Year				Total	%
	2008	2009	2010	2011		
January	24	14	21	27	86	6.7
February	15	37	29	21	102	8.0
March	29	30	33	18	110	8.6
April	31	31	25	15	102	8.0
May	23	32	20	25	100	7.8
June	18	39	22	35	114	8.9
July	25	41	22	36	124	9.7
August	20	48	23	38	129	10.1
September	25	15	32	27	99	7.8
October	27	19	33	28	107	8.4
November	32	22	37	33	124	9.7
December	15	12	24	20	71	5.6
Missing	4	2	1	0	7	0.5
Total	288	342	322	323	1275	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Table 4 describes that, there is a slight variation in the occurrence of RTAs among the months in Mekelle City. Comparatively, August, July are the months of highest RTA panorama in the city from 2008 to 2011 where they contribute 129 (10.1%) and 124 (9.7%) respectively of the total crashes during the study period. This could be mainly due to the effect of weather conditions i.e. Mekelle City receives its maximum amount of rainfall in July and August. Supporting this idea Alister and Simon (2011) have discussed that, many several crashes have occurred during conditions of fog, which can reduce visibility. Similar to the findings of this research, Samson (2006) indicated that July and August were found to have frequent RTAs in Addis Ababa between the years 1996 to 2005. However, Addis (2003) reported December, January and February to have the most common RTAs in Bahir Dar City.

5.1.2 Drivers Characteristics and Road Traffic Accidents

5.1.2.1 Drivers Age and RTA

Human beings are the primary causes of RTA. Several studies have witnessed that the age of drivers have a greater impact over the occurrence of RTA scenes. This is due to the fact that, the age of drivers affects their driving behavior, concentration, sense of responsibility and patience.

Table 5: Drivers age and RTA in Mekelle City (2008-2011)

Drivers Age in years	Accident year				Total	%
	2008	2009	2010	2011		
<18	5	7	9	6	27	2.1
18-30	158	189	192	185	724	56.8
31-50	104	128	101	111	444	34.8
>50	19	9	18	20	66	5.2
Missed	2	9	2	1	14	1.1
Total	288	342	322	323	1275	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Drivers between the ages of 18 and 30 are more frequently engaged in road crashes than drivers in the other age groups (Table 5). Drivers aged 18 to 30 contribute 724 (56.8%) of all the RTA crashes in the study period followed by age groups between 31 and 50 which contributes 444 (34.8%) to the misery. Driver age group above 50 years contributes only 66 (5.2%) road crashes in Mekelle during the study period. The underage car drivers/riders contribute for 27 (2.1%) of total crashes during the study period. Drivers found in the age group between 18 and 30 (young drivers) in the city are 1.63 times more frequently involved in RTAs than drivers aged 31 to 50 in Mekelle

City. Likewise, in general terms, Lisa, David et al. (2005) suggested that, young drivers are significantly more likely to be involved in a fatal crash than aged drivers. In addition to this, a study on drivers killed in road crashes estimated that young drivers are five times prone to the risk of crash accidents compared to the drivers aged above 30. This is mainly due to the fact that many exhibit behaviors and attitudes can place young drivers in more hazardous situations than other road users. Older drivers with slower reactions might be expected to cause in more accidents, but this has not been the case as they tend to drive less and, apparently, more cautiously.

5.1.2.2 Drivers Sex and RTA

The occurrence of RTA in Mekelle City shows a greater variation in terms of drivers' sex. As shown in figure 8, the number of male drivers involvement in RTAs greatly outnumbers females in Mekelle City. The outstrip number of male drivers could result in more frequencies of engaging in RTA events. From 2008 to 2011 male drivers cause 1253 (98.3%) RTAs in Mekelle. In contrary, female drivers caused 13 (1%) road crashes. In a very similar result Mekonnen (2007) have proved that, male drivers are the main contributors to RTAs than females in Addis Ababa. However, with this, conclusive remarks cannot be made due to the different proportions of male against female drivers.

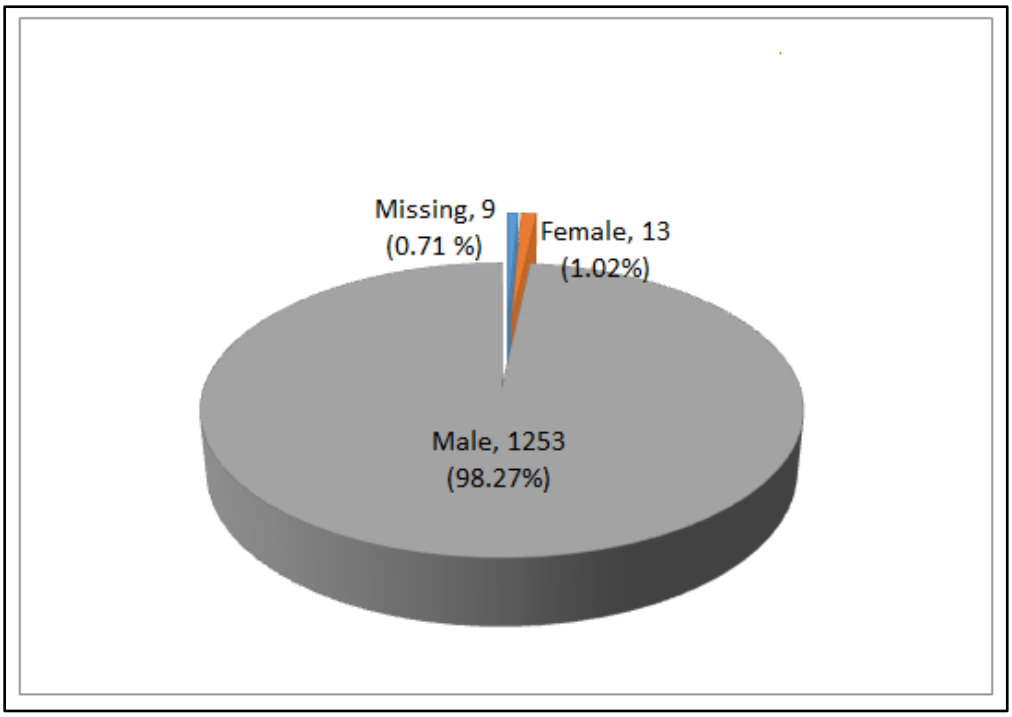


Figure 8: Drivers sex and their contribution to RTA in Mekelle City (2008-2011)

5.1.2.3 Drivers Driving Experience and RTA

It is believed that the experience of drivers play a paramount role in road crashes. The distributions of road crashes in Mekelle City are also affected by the driving experience. Table 6 summarizes the difference in RTA occurrences in relation to driving experience.

Table 6: Driving experience and RTA in Mekelle City (2008-2011)

Drivers Driving Experience in years	Accident year				Total	%
	2008	2009	2010	2011		
<1	27	15	22	32	96	7.5
1-5	120	92	127	132	471	36.9
6-10	37	38	38	58	171	13.4
11-15	19	6	12	20	57	4.5
16-20	12	2	7	12	33	2.6
21-25	4	0	5	5	14	1.1
26-30	2	1	4	11	18	1.4
31-35	0	2	1	2	5	0.4
>35	0	0	1	0	1	0.1
Missed	67	186	105	51	409	32.1
Total	288	342	322	323	1275	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Table 6 illustrates 471 (36.9% RTA incidences have been exhibited by drivers whose driving experience is between 1 to 5 years. The drivers with driving experience between 6 and 10 years have caused 171 (13.4%) road crashes in the study period. In addition to this, with the exception of the drivers in their first year experience, the result shows that the frequencies of RTA occurrences decrease with increasing in driving experience in Mekelle City. Drivers with an experience of 1 to 5 years cause 2.75 times more road crashes than drivers with driving experience between 6 and 10 years. This result in Mekelle City is found conflicting with the correlation between driving experience of drivers and frequency of their involvement in road crashes in Addis Ababa city. This is because, as stated by Mekonnen (2007), the highly experienced drivers are engaged in frequent RTA scenarios than the least experienced ones in Addis Ababa.

5.1.2.4 Hired Driver – Own drivers vis-à-vis RTA

The incident of RTA was evaluated against driver and vehicle ownership. Figure 9 illustrates how far the drivers – vehicle ownership relationship contributes to RTA occurrences in Mekelle City. About 1007 (79%) of RTAs are recorded from hired drivers. Ironically, 189 (14.8%) of accidents were accompanied by owners of the vehicle while

driving their own vehicles. Similar to this finding, Mekonnen (2007) argued that hired drivers were engaged in frequent RTAs in Addis Ababa when compared to the vehicle owners. The low accident caused by own drivers' is mainly attributed to the strong sense of ownership feeling, belongingness and responsibility.

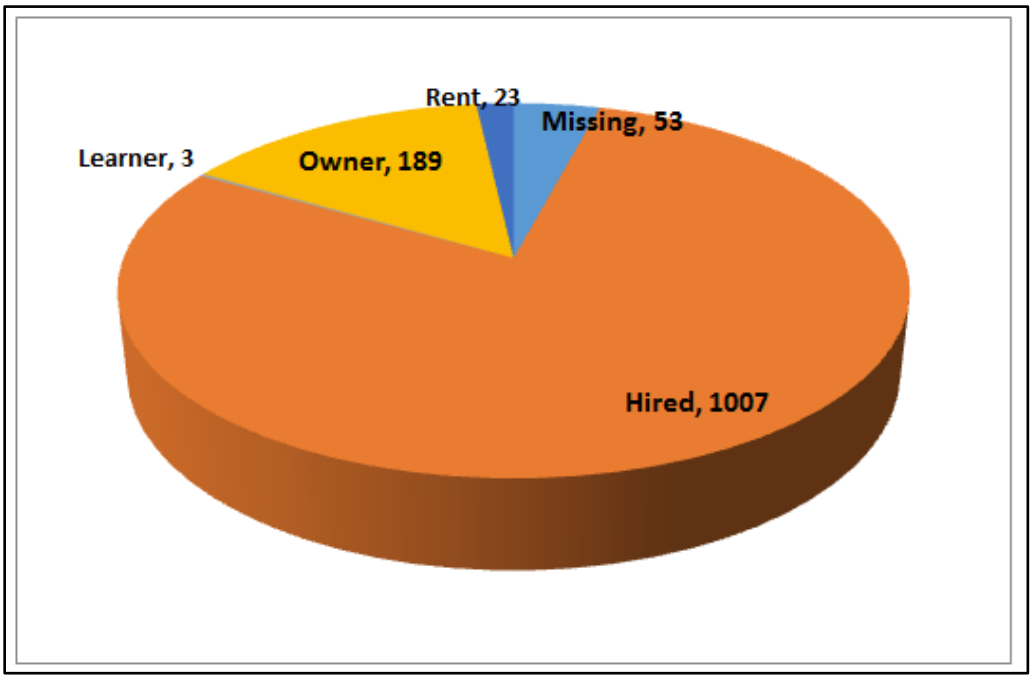


Figure 9: Hired Drivers – own drivers vis-à-vis RTA in Mekelle City (2008-2011)

5.1.3 Vehicle Characteristics and Road Traffic Accidents

5.1.3.1 Vehicle Service Age and RTA

The vehicle service age determines the fate of the vehicle to be engaged in RTA Crashes. The RTA data collected from Mekelle City Traffic office, as shown in table 7 reveals that the vehicle service age determines the variation in the distribution of RTA throughout the study period.

Table 7: Vehicle service age and RTA in Mekelle City (2008-2011)

Vehicle service age in years	Accident year				Total	%	Average Driving Experience of Drivers in Years
	2008	2009	2010	2011			
0 – 5	121	58	106	112	397	31.1	5.56
6 – 10	89	57	98	149	393	30.8	6.4
11- 25	2	1	4	9	16	1.3	11.14
old	0	0	0	2	2	0.15	5
Missed	76	226	114	51	467	36.6	5.32
Total	288	342	322	323	1275	100.0	

Source: Compiled from Mekelle City Traffic Office (2012)

Vehicles with service age between 0 and 5, and 6 to 10 years caused RTA 397 (31.1%) and 393 (30.8%) respectively. As the service age of vehicles is high, for example, between 11 and 25 years, the probability of road crashes in the city decreases. This is because:

1. Driving experience: The average driving experience of drivers who drove vehicles with a service age of 0 to 5 and 6 to 10 years was 5.56 and 6.4 years respectively while vehicles with a service year of 11 to 25 were driven by drivers whose average driving experience was 11.14 years.

2. Speed of the vehicles: vehicles of old age have low speed compared to the new ones.

3. New vehicles become less familiar to the drivers. Most of the break system, comfort during driving and self-confidence on controlling the vehicles are some of the reasons. The over confidence of drivers on relatively newer vehicles and the lesser attention they gave to the vehicle inspection of new vehicles could result in higher frequency of involvement of new vehicles in RTAs. The probability of vehicles service age contribution to RTA in the city would be a little bit different if the service age of the 36.6% of the vehicles which produced 467 crashes was known.

5.1.3.2 Vehicle Category and RTA

Several vehicle categories have been involved in RTA scenes in the city in the last four years**.** The entire types or model of vehicles in the city in relation to their contribution to road crashes in the last four years is attached under Appendix 2.

Table 8: Vehicle Category and RTA in Mekelle City (2008-2011)

Vehicle Category	Vehicle Type	Accident Year				Total	%
		2008	2009	2010	2011		
Public Transport	Minibus	41	49	52	58	200	15.7
	Three Wheel Motor (Bajaj)	36	32	34	37	139	10.9
	Bus	9	17	13	6	45	3.5
Freight Transport	Trucks	78	55	68	83	284	22.3
Automobile		7	7	9	12	35	2.7
Bicycle		13	17	7	14	51	4.0
Motor Bicycle		5	5	2	1	13	1.0
Horse Cart		7	19	30	14	70	5.5
Unclassified		75	86	88	86	335	26.3
Missing		17	55	19	12	103	8.1
Total		288	342	322	323	1275	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Vehicles serving for public transport are more frequently involved in RTAs than other vehicle categories (Table 8). Vehicles of Public transport at an average cause 384 (30.11%) road crashes every year. In addition, among the public transport vehicle category, Minibuses encounter road crashes more frequently. This is followed by three – wheel motors (Bajaj) and Buses. The unclassified vehicle categories which includes land cruisers, cranes, loaders and station wagons together contribute for 335 (26.3%) of the total crash in Mekelle. Moreover, the freight transport category which includes trucks also adds up 284 RTA scenes. The relatively higher frequency of Minibuses and the three – wheeled motors (Bajaj) involvement in the road crashes of the city can be attributed to frequent trips to transport passengers, lack of driving skills and exhaustion from driving long hours.

5.1.4 Road Characteristics and Road Traffic Accidents

5.1.4.1 Road divide and RTA

Based on the RTA data collected in the study period, the two – way road division types produce 785 (61.6 %) of all the road crashes, while the one – way roads contribute for 257 (20.2%) of RTAs (Figure 10). The frequency of road crashes in two-way roads is by far higher than in the one-way roads. This is because two-way roads host the movement of vehicles from opposite directions in the same stream and are usually characterized by traffic congestion. However, the one-way roads have a divide line which separates vehicles in to two and enables them to move only in one direction and allows vehicles to move in a relatively safer route than in the two-way roads. Due to this reason, two – way roads are more than three times more risky to RTA occurrences than one – way roads in Mekelle City. The squares of the city are also places of some RTA occurrences. About 38 (3%) of road crashes are recorded at or near the road junction and roundabouts. The remaining 11 accidents or (0.9%) and 3 accidents or (0.2%) happen in cross ways and inside the surrounding of different institutions respectively.

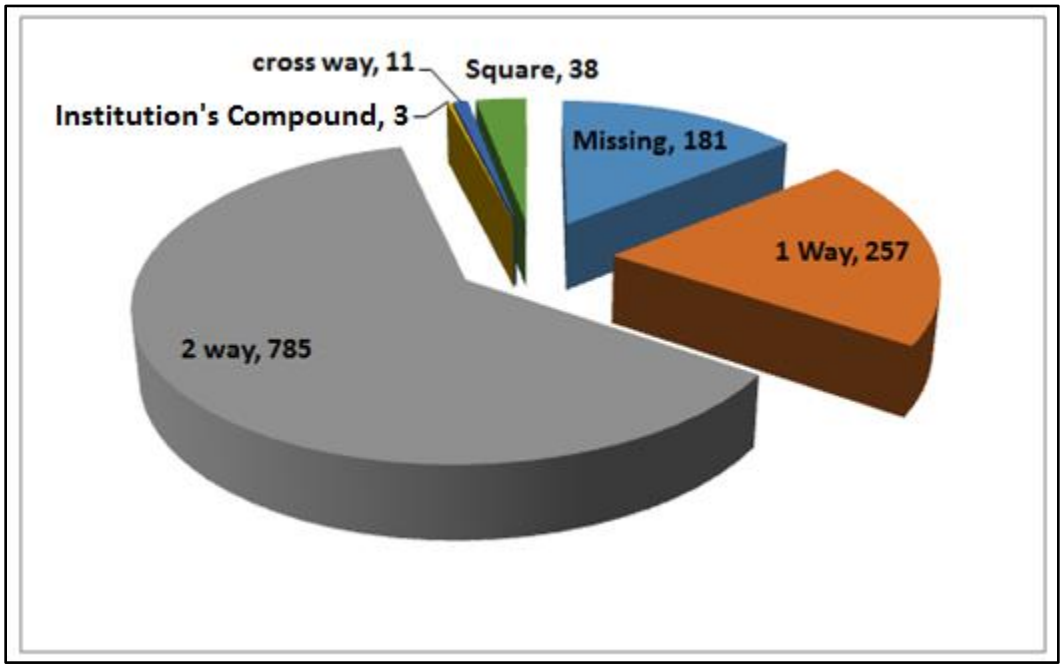


Figure 10: Road divide and RTA in Mekelle City (2008-2011)

5.1.4.2 Road Pavement and RTA

Road's pavement is found as the major contributing variable for the occurrence of RTAs in Mekelle City since it is directly related to the speed of the vehicle. Drivers prefer to drive in higher speeds in smoother road pavements like in asphalt roads. Consequently, About 915 (71.8%) of all the accidents has occurred on asphalt roads. Gravel roads and cobblestone covered roads contribute 207 (16.2%) and 23 (1.8%) between the years 2008 to 2011 respectively (Figure 11). Drivers have high precaution at hazard locations compared to low hazard locations. This is to mean in places where drivers perceive a location as hazardous, they take more care. Accidents may be more likely to happen when hazardous road or traffic conditions are not obvious at a glance, or where the conditions are too complicated to perceive and react in the time and distance available.

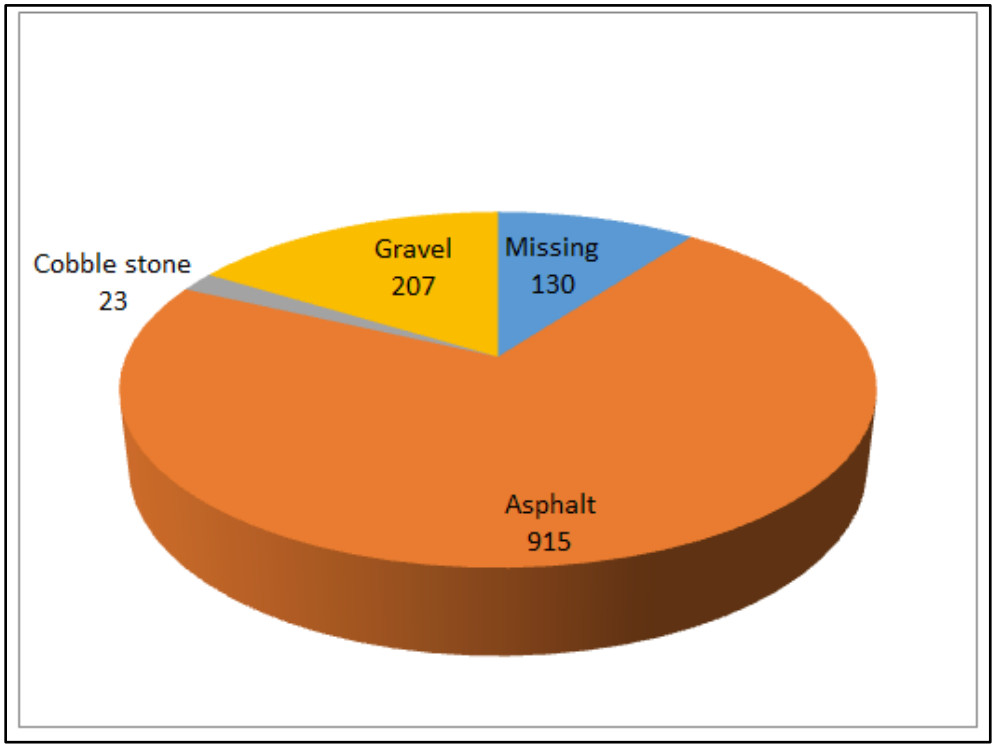


Figure 11: Road Pavement and RTA in Mekelle City (2008-2011)

5.1.4.3 Road Moisture Condition and RTA

As stated by Lisa, David et al. (2005), the condition of road weather strongly affects the occurrence of RTAs. Similarly, RTA is found to vary according to weather (Figure 12). The road condition due to differences in moisture is classified as dry or wet road. Accordingly, out of the total 1275 RTA records in the last four years in the city 1230 (96.5%) have occurred on dry roads while 45 (3.5%) on wet roads in Mekelle City. This may be due to the short wet season (little number of rainy days) in a year, the dry season or dry weather which shields the extensive number of days in a year in the city therefore produces greater number of road crashes.

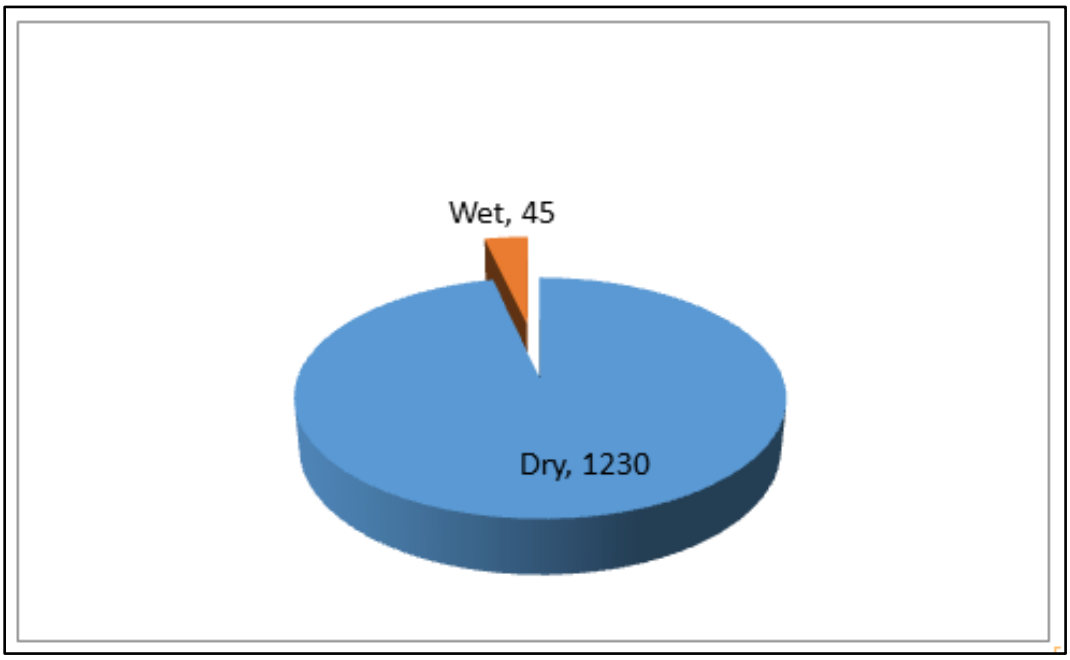


Figure 12: Road moisture condition and RTA in Mekelle City (2008-2011)

5.1.5 Weather Condition and Road Traffic Accidents

The weather condition of the moment in RTAs plays an important role in varying the frequency and risk of road crashes. (Lisa, David et al. 2005); Alister and Simon (2011) stated that the climatic and environmental conditions can be a factor in RTAs. Experiences show that several crashes occur during conditions of smoke or fog, which reduces visibility. Road Traffic Accidents in Mekelle City frequently occur during good weather conditions than during rainy and drizzle falling events. Accordingly, 1246 (97.7%) RTAs in the city have been recorded in good weather conditions but only 22

(1.7%) and 7 (0.5%) accidents recorded in rainy and drizzle falling weather conditions respectively. Bright and dry weather of the city which covers the longer days of the year in the city produces greater number of RTAs than the rainy and drizzle falling weather conditions.

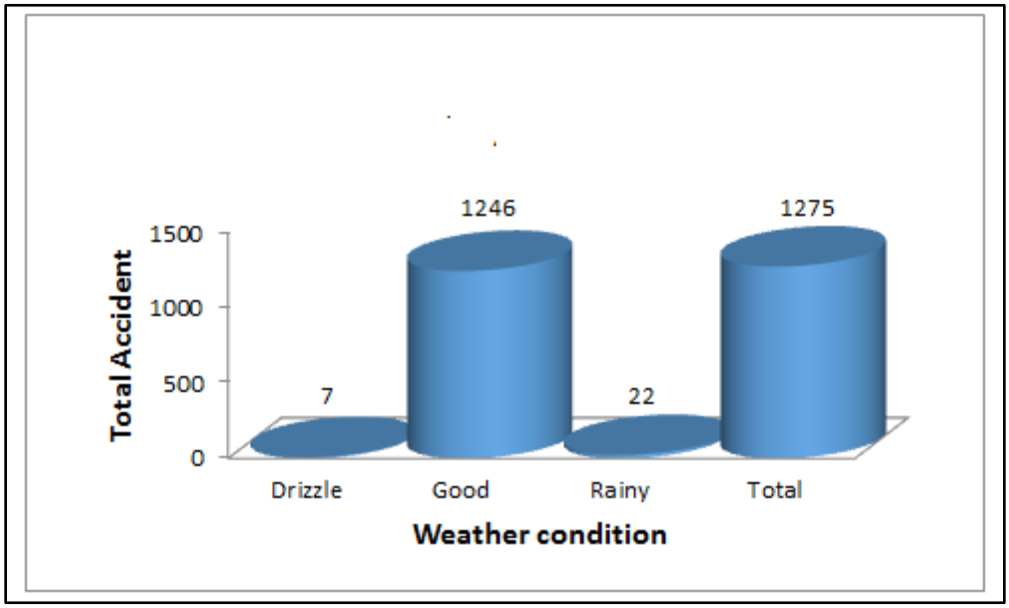


Figure 13: Weather condition and RTA in Mekelle City (2008-2011)

5.1.6 Types of Road Traffic Accidents

Road Traffic Accidents can happen in various ways. Safecarguide (2004) indicated the type of RTA may include collision between vehicles and animals, vehicles and pedestrians or vehicles and fixed obstacles. This shows that RTA can have a varied ways. The major types of RTA in Mekelle City are shown in the table to follow.

Table 9: Types of RTA in Mekelle City (2008-2011)

Accident type	Accident year				Total	%
	2008	2009	2010	2011		
Missing	5	12	1	0	18	1.4
Bicycle to Pedestrian	5	6	1	0	12	0.9
Bicycle to Vehicle	4	4	1	9	18	1.4
Horse Cart crash	0	0	0	1	1	0.1
Horse Cart to Material	0	0	0	1	1	0.1
Horse Cart to Motor bicycle	0	1	0	0	1	0.1

Accident type	Accident year				Total	%
	2008	2009	2010	2011		
Horse Cart to Pedestrian	0	7	2	2	11	0.9
Horse Cart to Vehicle	5	7	20	7	39	3.1
Motor bicycle crash	1	0	0	0	1	0.1
Motor bicycle to Vehicle	0	1	0	0	1	0.1
Vehicle crash	25	38	27	21	111	8.7
Vehicle to Animal	8	14	7	5	34	2.7
Vehicle to Bicycle	0	3	2	4	9	0.7
Vehicle to Horse cart	0	7	6	2	15	1.2
Vehicle to Material	21	22	39	30	112	8.8
Vehicle to Motor bicycle	0	0	1	0	1	0.1
Vehicle to Pedestrian	69	72	54	78	273	21.4
Vehicle to Vehicle	145	148	161	163	617	48.4
Total	288	342	322	323	1275	100

Source: Compiled from Mekelle City Traffic Office (2012)

The RTA occurred in the city between the study periods are of varied types and their contribution to the road crashes also vary considerably. The vehicle to vehicle crash gets the biggest proportion i.e. 617 (48.4%) of RTA crashes of all types of RTAs in the city followed by vehicle to pedestrian crashes which covers 273 RTA scenes and 21.4% share of the RTA occurrences from 2008 to 2011 in Mekelle City (Table 9). In the remaining cases, with the exception of Vehicle to material and vehicle crush types which covers 8.8% and 8.7% of the road crashes respectively, the rest have relatively insignificant contribution to road crashes in Mekelle City. Pedestrians have been engaged in 296 RTA cases i.e. 273 with vehicles, 12 with bicycle and 11 with horse cart. In addition to this, vehicles, Horse cart and bicycles are engaged in 1212, 68 and 39 RTA occurrences in the study period.

5.2 The Spatio-Temporal Distribution of Road Traffic Accident Spots and Road Traffic Accident Black Spots in Mekelle City

5.2.1 The Spatial Distribution of RTAs and RTA Spots in Mekelle City in 2008

In 2008, Mekelle City exhibits the occurrence of 272 spatially identified RTAs. The RTAs were unevenly distributed throughout the Sub-cities of Mekelle City administration in this year.

Table 10: The spatial distribution of RTA occurrences in Mekelle City (2008)

Year	Sub-city	No. of RTA Spots	No. of RTAs occurred	% of RTA Spots	% of RTAs occurred
2008	Semen and its extension	38	109	38	40.1
	Quiha	14	35	14	12.9
	Hawelti	13	40	13	14.7
	Hadinet and its extension	11	36	11	13.2
	Ayder	2	5	2	1.8
	Kedamay Weyane	18	42	18	15.4
	Adihaki	4	5	4	1.8
	Total	100	272	100	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

The above table 10 stipulates that, 272 RTAs were recorded form 100 RTA spots in the city in 2008. This indicates that an average of 2.72 RTAs have occurred at every RTA spots in the city in 2008. The highest numbers of RTA spots as well as the largest frequency of RTA incidents were recorded from Semen sub-city and its extension. Semen sub-city and its extension exhibits 109 (40.1%) of RTAs and 38 (38%) of RTA spots in the city by 2008. Kedamay Weyane sub-city produced 42 (15.4%) of RTAs unveiled in 18 (18%) RTA spots followed by Hawelti sub-city which shares 40 (14.7%) RTAs happened in 13 (13%) RTA spots. The RTAs have been fairly distributed amongst Hadinet sub-city and its extension and Quiha sub-city since 36 (13.2%) and 35 (12.9%) RTAs occurred in the sub-cities respectively. Ayder sub-city and Adihaki sub-city showed 5 (1.8%) RTAs each in 2 (2%) and 4 (4%) RTA spots respectively. The spatial distribution of RTA spots in Mekelle City by the year 2008 is shown in figure 14.

5.2.1.1 Spatial Distribution of RTA Black Spots of Mekelle City in 2008

According to the criteria set, all places that exhibit five or more than five RTAs were defined as RTA Black spots. Accordingly, as shown in table 11 and figure 15; 14 places were identified as RTA Black spots in Mekelle City in the year 2008.

Table 11: Mekelle City RTA Black Spot areas (2008)

Year	RTA Black Spot area	Black Spot code	No. of RTAs occurred in the Black spot
2008	Messebo Mountain	163	6
	Lachi	137	10
	Trans Ethiopia	238	16
	Donbosco	65	10
	Mesfin Industrial Engineering	165	5
	Mobil	172	11
	Dedebit Micro Finance	61	15
	Health Station	108	5
	Kebelle 18	129	5
	Adihawsi	12	5
	Mekelle University, Arid campus	158	11
	May Shibti	151	6
	Air force	19	8
	Yetebaberut, Endasilassie	245	11
Total	14		124

Source: Compiled from Mekelle City Traffic Office (2012)

According to table 11, a total of 124 RTAs have been recorded from only 14 RTA black spots in the city in the year 2008. This implies that, an average of 8.85 RTA incidences have occurred at every single RTA Black spot in the city in the year 2008. The highest frequency of RTAs i.e. 16 happened around Trans Ethiopia area in 2008. In addition to this, 6 out of the 14 RTA black spots of the city in this year have occurred in the Semen sub-city and its extension. Hadinet and its extension and Quiha sub-cities shared 3 and 2 RTA Black Spots respectively. Ironically, Adihaki, Kedamay weyane and Hawelti sub-cities exhibited only 1 RTA black spot area each in the year while Ayder sub-city had nil.

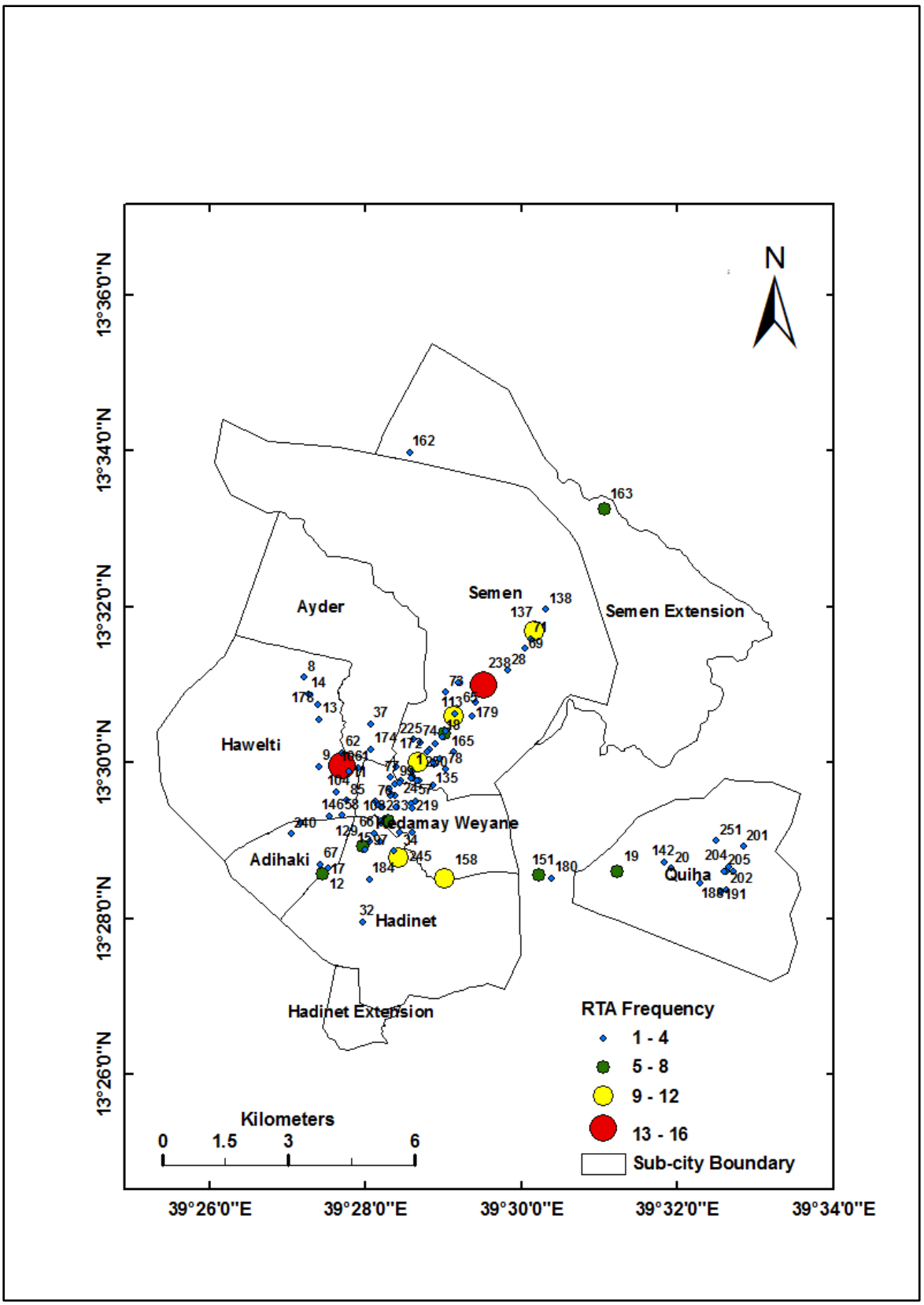


Figure 14: Spatial Distribution of RTAs and RTA Spots in Mekelle City (2008)

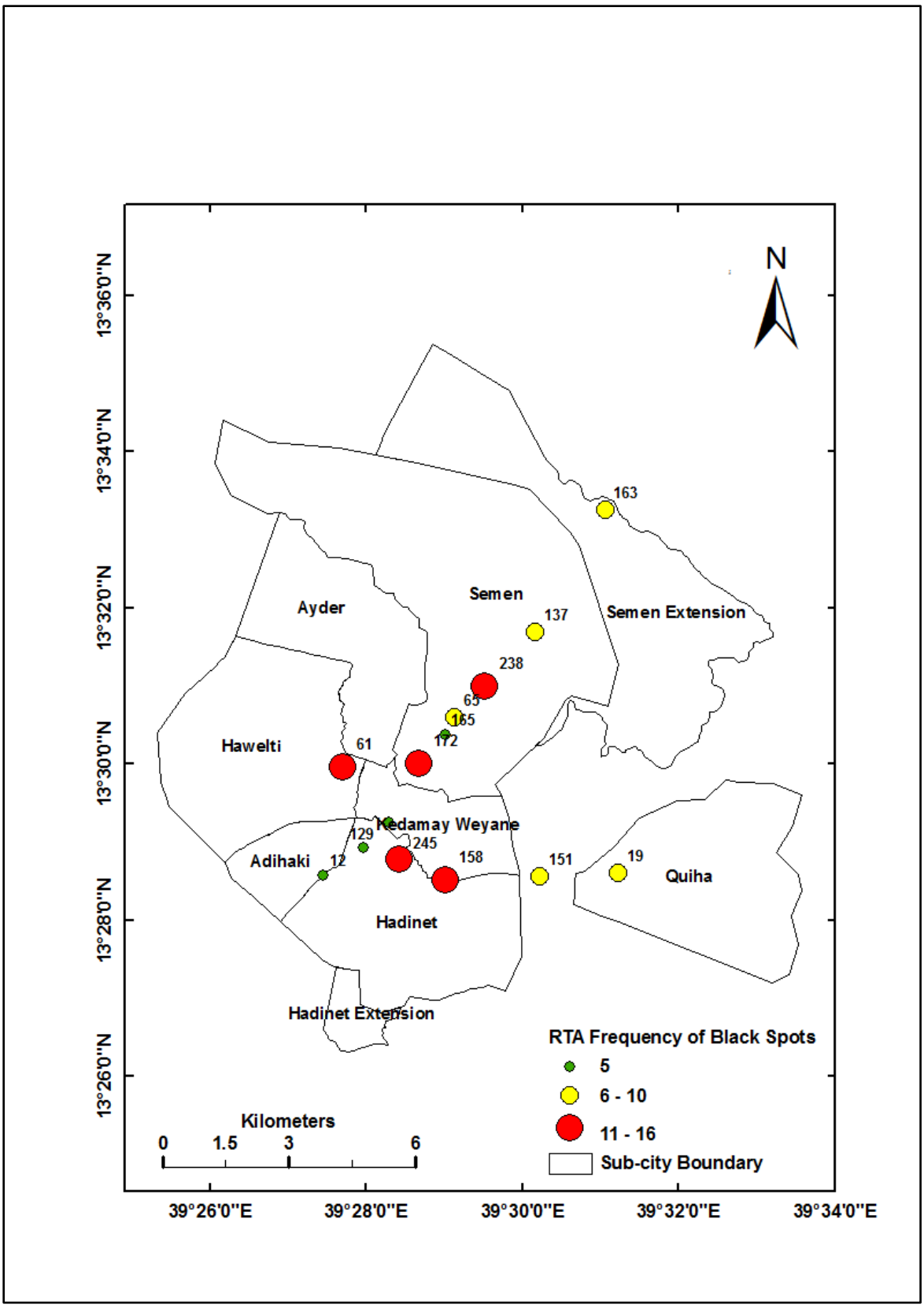


Figure 15: Spatial Distribution of RTA Black Spots in Mekelle City (2008)

5.2.2 The Spatial Distribution of RTAs and RTA Spots in Mekelle City in 2009

In 2009, Mekelle City exhibits 279 spatially identified RTAs. The frequency of RTAs was randomly distributed throughout the Sub-cities of Mekelle City administration in this year.

Table 12: The spatial distribution of RTA occurrences in Mekelle City (2009)

Year	Sub-city	No. of RTA Spots	No. of RTAs occurred	% of RTA Spots	% of RTAs occurred
2009	Semen and its extension	36	143	37.5	51.3
	Quiha	15	34	15.6	12.2
	Hawelti	16	35	16.7	12.5
	Hadinet and its extension	18	50	18.8	17.9
	Ayder	0	0	0.0	0.0
	Kedamay Weyane	9	14	9.4	5.0
	Adihaki	2	3	2.1	1.1
	Total	96	279	100.0	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Table 12 specifies that, 279 RTAs have been recorded form 96 RTA spots in the city in 2009. This indicates an average of 2.9 RTAs have occurred at every RTA spots in the city by 2009. As the same to the year 2008, the highest numbers of RTA spots as well as the largest frequency of RTA incidents are recorded from Semen sub-city and its extension in 2009. Semen sub-city and its extension exhibited 143 (51.3%) of RTAs and 36 (37.5%) of RTA spots in the city by 2009. Hadinet sub-city and its extension produced 50 (17.9%) of RTAs shown in 18 (18.8%) RTA spots followed by Hawelti and Quiha sub-cities which shares 35 (12.5%) and 34 (12.2%) of RTA happenings in 16 (16.7%) and 15 (15.6%) RTA Spots respectively. Adihaki sub-city showed only 3 (1.1%) RTAs unveiled from 2 (2.1%) RTA Spots in this year. Any RTA record has not been found for Ayder sub-city in 2009. But this may not necessarily mean that a single RTA has not occurred in the sub-city in the whole year because several RTA data of 2008 and 2009 have been lost form the Mekelle city Traffic office RTA recording file. The spatial distribution of RTA spots in Mekelle city by the year 2009 is shown in figure 16.

5.2.2.1 Spatial Distribution of RTA Black Spots of Mekelle City in 2009

As described in table 13 and figure 17, 18 places were identified as RTA Black spots in Mekelle City in 2009. Compared to 2008, the number of RTA Black spots as well as the frequency of RTAs occurred on the black spots have shown an increasing trend by 4 and by 23 respectively.

Table 13: Mekelle City RTA Black Spot areas (2009)

Year	RTA Black Spot area	Black Spot code	No. of RTAs occurred in the Black spot
2009	Kebell 17 Market	128	5
	Kidane Mihret Church front	135	5
	Lachi	137	8
	MAA Garment	142	5
	Mesebo Cement Factory	162	7
	Mesebo Mountain	163	6
	Mesfin Industrial Engineering	165	6
	Mobil	172	18
	NOC	179	6
	Agip	18	7
	Northern Command	180	5
	Saturday Market	212	8
	Trans Ethiopia	238	14
	Yetebaberut, Endasilassie	245	12
	City Area	50	5
	Dr. Fitsum Hospital	66	7
	Elala	69	11
	Enda Gabir church	74	12
Total	18		147

Source: Compiled from Mekelle City Traffic Office (2012)

According to Table 13, a total of 147 RTAs have been recorded from 18 RTA black spots in the city in the year 2009. This implies that, an average of 8.16 RTA incidences have occurred at every single RTA Black spot in the city in the year 2009. The highest frequency of RTAs i.e. 18 happened in Mobil area in 2009. In addition to this, 12, 3, 2 and 1 out of the 18 RTA black spots of the city in this year have occurred in the Semen sub-city and its extension, Hadinet sub-city and its extension, Quiha sub-city and Hawelti sub-city respectively. In opposite to this, none of the RTA Black spots have recorded from the remaining 3 sub-cities in this year.

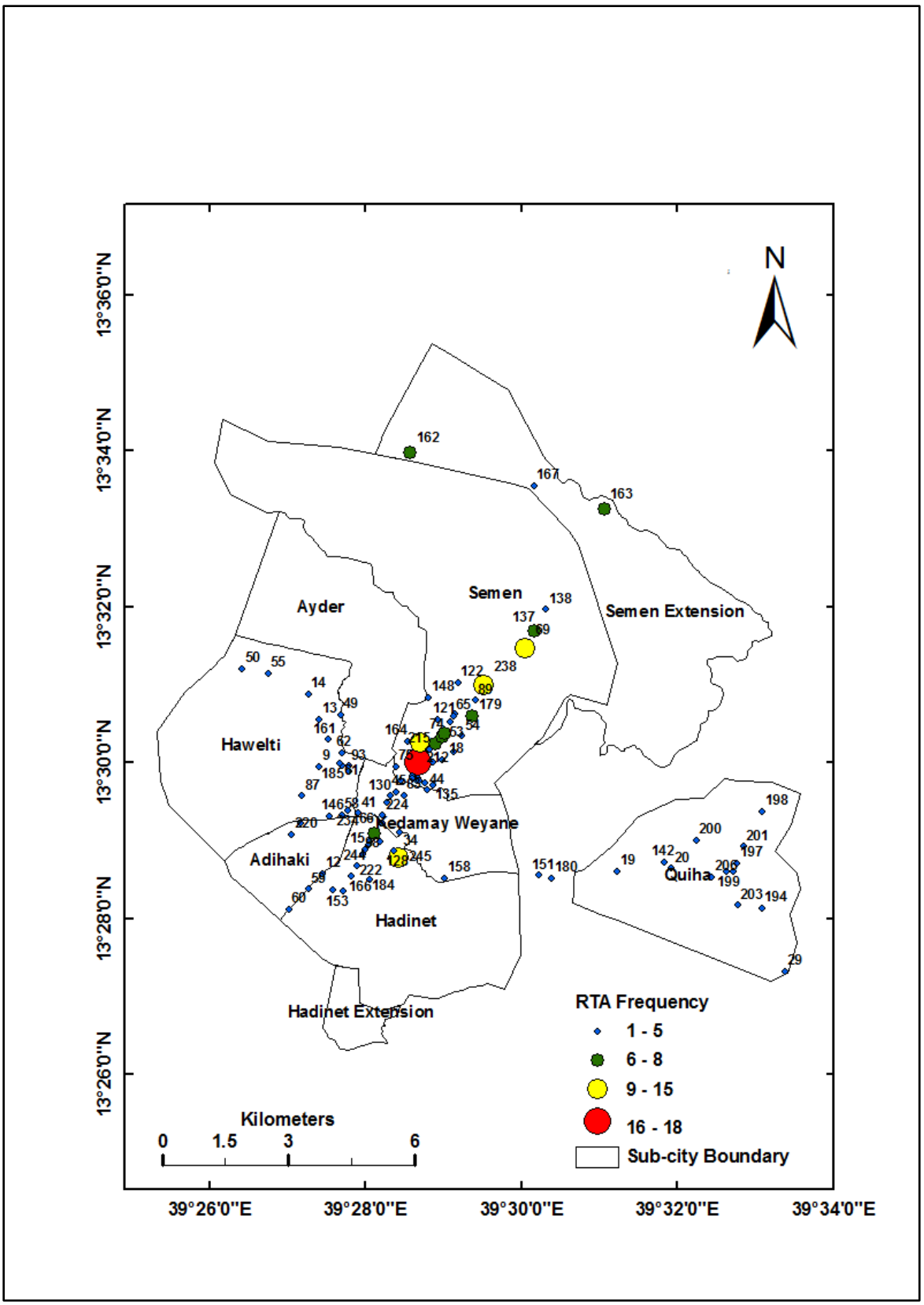


Figure 16: Spatial Distribution of RTAs and RTA Spots in Mekelle City (2009)

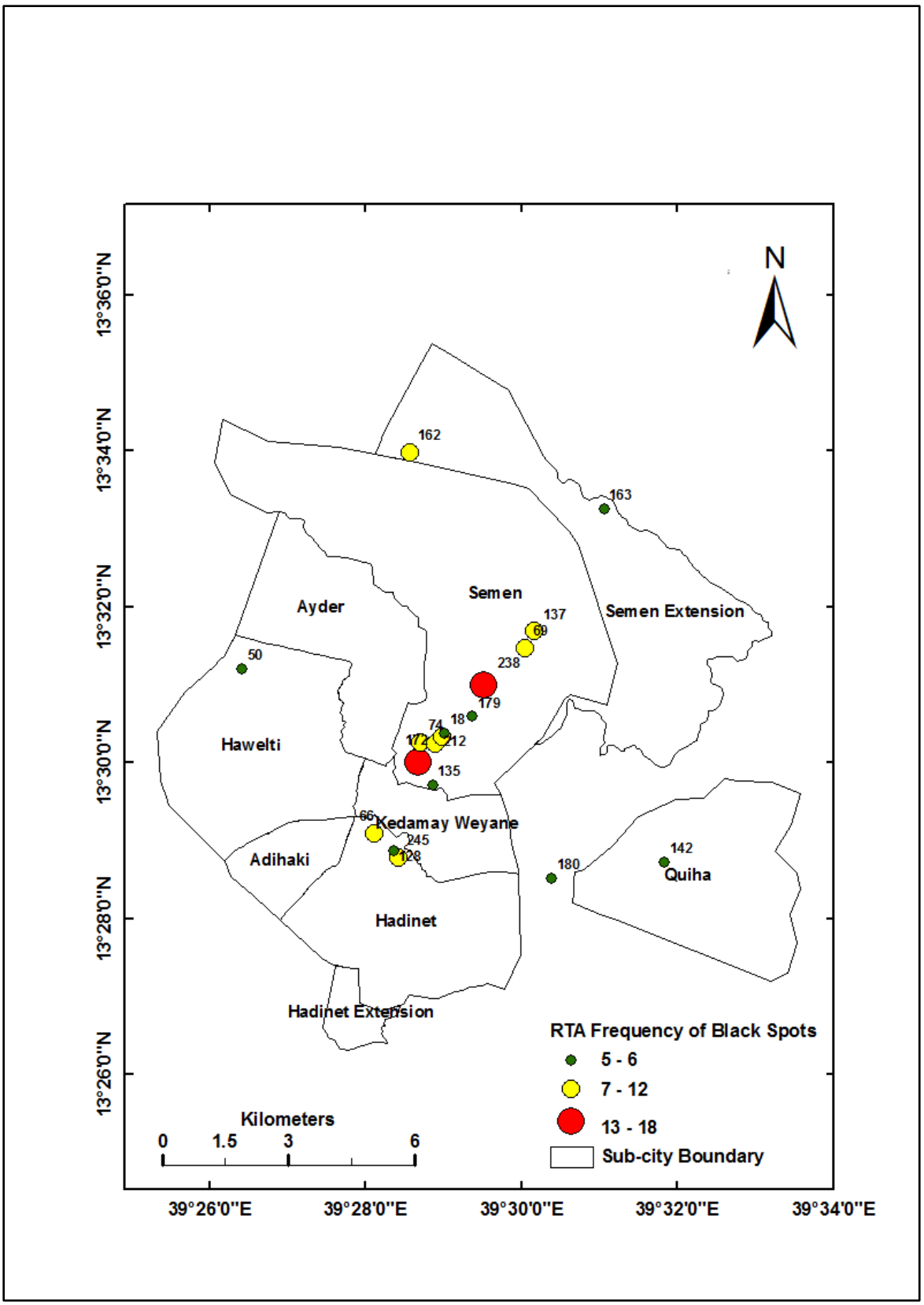


Figure 17: Spatial Distribution of RTA Black Spots in Mekelle City (2009)

5.2.3 The Spatial Distribution of RTAs and RTA Spots in Mekelle City in 2010

In 2010, Mekelle City exhibits the occurrence of 295 spatially identified RTAs. The frequency of RTAs is irregularly distributed throughout the Sub-cities in 2010.

Table 14: The spatial distribution of RTA occurrences in Mekelle City (2010)

Year	Sub-city	No. of RTA Spots	No. of RTAs occurred	% of RTA Spots	% of RTAs occurred
2010	Semen and its extension	37	101	28.0	34.2
	Quiha	11	17	8.3	5.8
	Hawelti	15	49	11.4	16.6
	Hadinet and its extension	19	49	14.4	16.6
	Ayder	3	7	2.3	2.4
	Kedamay Weyane	44	62	33.3	21.0
	Adihaki	3	10	2.3	3.4
	Total	132	295	100.0	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Table 14 postulates that, 295 RTAs have been recorded form 132 RTA spots in the city in 2010. This indicates an average of 2.23 RTAs have occurred at every RTA spots in the city by 2010. Like in the preceding years, the highest numbers of RTA spots are recorded from Semen sub-city and its extension by 2010. However, the highest number of RTA Spots shifted from Semen sub-city and its extension to Kedamay weyane sub-city in this year. The opening of Kedamay Weyane shopping mall and other related businesses results in increasing the traffic volume in Kedamay Weyane sub-city. Semen sub-city and its extension exhibited 101 (34.2%) of RTAs and 37 (28%) of RTA spots in the city by 2010. Kedamay Weyane sub-city takes the share of 62 (21%) RTAs and 62 (33.3%) of the RTA Spots in the year. Hadinet sub-city and its extension and Hawelti sub-cities produced 49 (16.6%) of RTAs each shown in 19 (14.14%) and 15 (11.4%) RTA spots respectively. Ayder sub-city which produced the least RTAs and RTA Spots in the previous years contributed for 7 (2.4%) RTA incidents from 3 (2.3%) RTA Spots in 2010. The spatial distribution of RTA spots in Mekelle City by the year 2010 is shown in figure 18.

5.2.3.1 Spatial Distribution of RTA Black Spots of Mekelle City in 2010

As described in table 15 and figure 19, 13 places are identified as RTA Black spots in Mekelle City in 2010. Comparing to 2009, the number of RTA Black spots as well as the frequency of RTAs occurred in the black spots have shown a decreasing trend by 5 and by 54 respectively.

Table 15: Mekelle City RTA Black Spot areas (2010)

Year	RTA Black Spot area	Black Spot code	No. of RTAs occurred in the Black spot
2010	Adi Haqi Market	11	5
	Lachi	137	9
	Martyrs Monument	146	5
	Mekelle university, Arid Campus	158	5
	Mesebo Mountain	163	8
	Mesfin Industrial Engineering	165	5
	Settlement Area	220	6
	Total	237	5
	Trans Ethiopia	138	10
	Yetebaberut, Endasilassie	245	13
	Ayder Referral Hospital	37	5
	Dedebit Micro Finance	61	11
	Donbosco	65	6
Total	13		93

Source: Compiled from Mekelle City Traffic Office (2012)

According to table 15, a total of 93 RTAs have been recorded from 13 RTA black spots in the city in the year 2010. This implies that, an average of 7.15 RTA incidences have occurred at every single RTA Black spot in the city in the year 2010. The highest frequency of RTAs i.e. 13 happened in Yetebaberut, Endasilassie area in 2010. In addition to this, 6 out of the 13 RTA black spots of the city in this year have occurred in the Semen sub-city and its extension. Hawelti and Hadinet and its extension sub-cities shared 3 and 2 RTA Black Spots respectively while Ayder and Adihaki sub-cities comprise 1 RTA Black Spot each in the year. Atypically, none of the RTA Black spots have recorded from Quiha and Kedamay Weyane sub-cities.

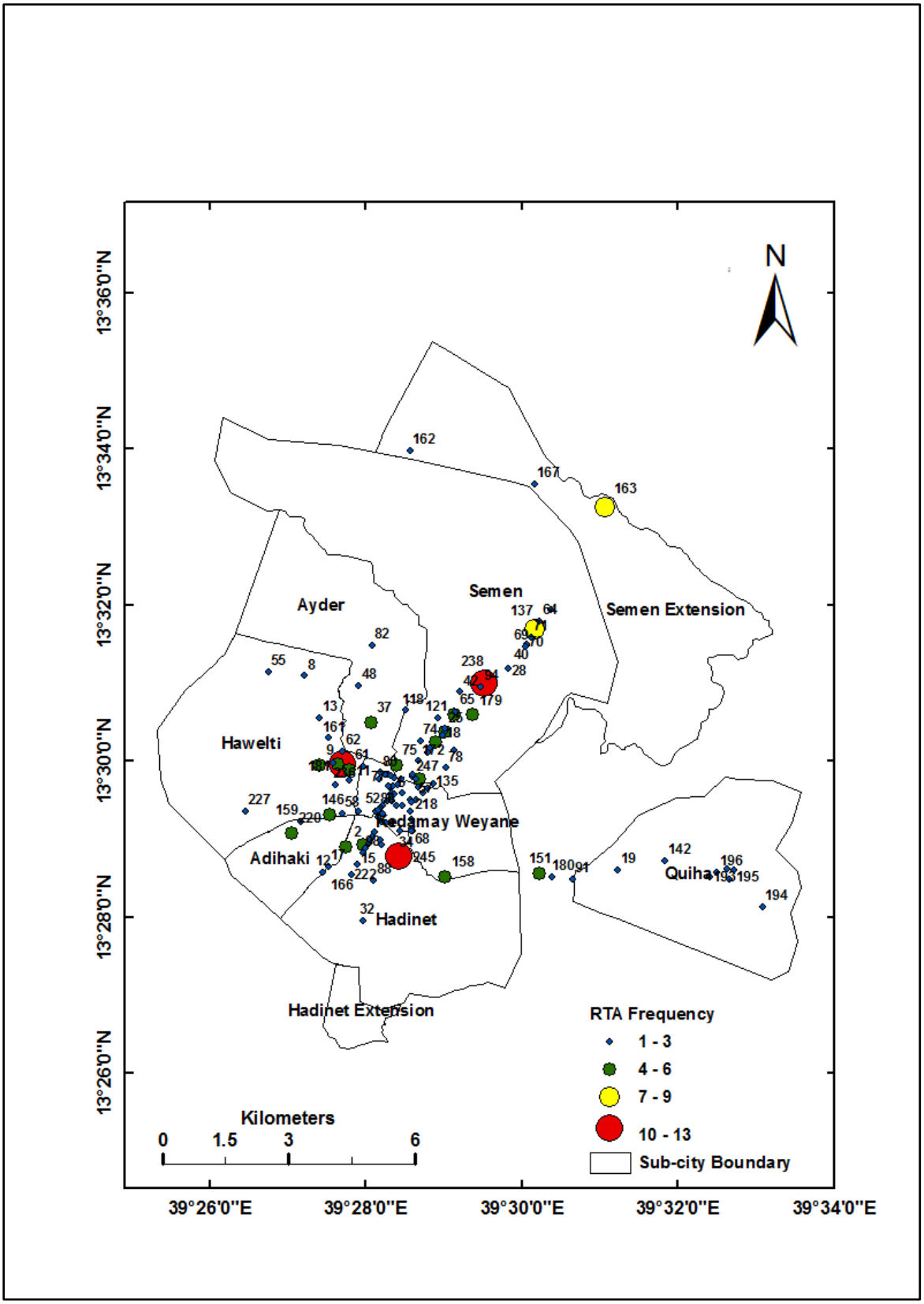


Figure 18: Spatial Distribution of RTAs and RTA Spots in Mekelle City (2010)

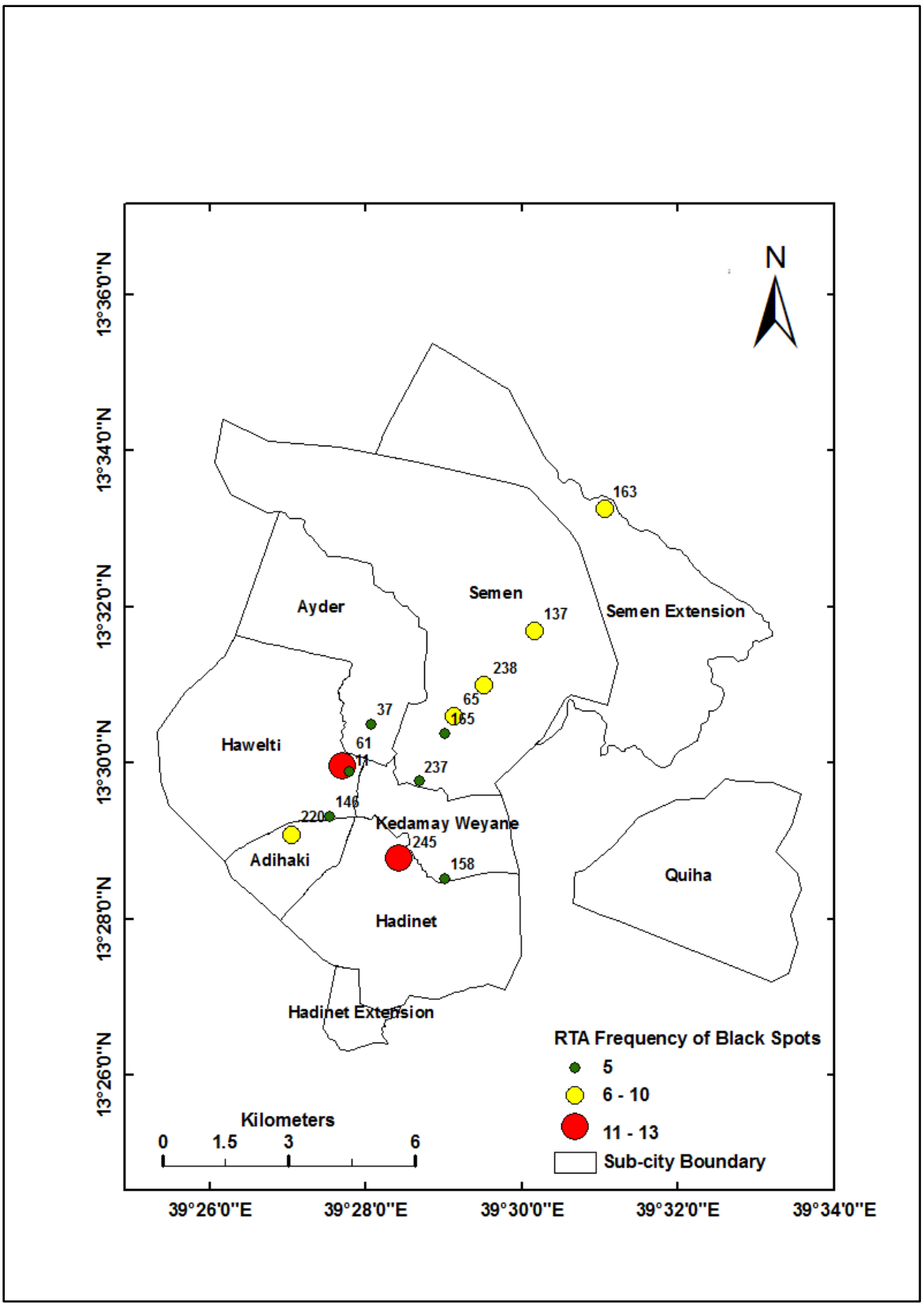


Figure 19: Spatial Distribution of RTA Black Spots in Mekelle City (2010)

5.2.4 The Spatial Distribution of RTAs and RTA Spots in Mekelle City in 2011

In 2011, Mekelle City exhibits the occurrence of 315 spatially identified RTAs. The frequency of RTAs is randomly distributed throughout the Sub-cities of Mekelle City administration in this year.

Table 16: The Spatial distribution of RTA occurrences in Mekelle City (2011)

Year	Sub-city	No. of RTA Spots	No. of RTAs occurred	% of RTA Spots	% of RTAs occurred
2011	Semen and its extension	49	119	33.1	37.8
	Quiha	10	21	6.8	6.7
	Hawelti	16	38	10.8	12.1
	Hadinet and its extension	15	42	10.1	13.3
	Ayder	6	9	4.1	2.9
	Kedamay Weyane	47	77	31.8	24.4
	Adihaki	5	9	3.4	2.9
	Total	148	315	100.0	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

The above table 16 shows that, 315 RTAs have been recorded form 148 RTA spots in the city in 2011. This indicates that, an average of 2.12 RTAs has occurred at every RTA spots in the city by 2011. Like in 2008 and 2009, the highest numbers of RTA spots as well as the largest frequency of RTA incidents are recorded from Semen sub-city and its extension. Semen sub-city and its extension exhibited 119 (37.8%) of RTAs and 49 (33.1%) of RTA spots in the city by 2011. Kedamay Weyane sub-city hosted 77 (24.4%) of RTAs occurred in 47 (31.8%) RTA spots followed by Hadinet sub-city and its extension which shares 42 (13.3%) RTAs occurances in 15 (10.1%) RTA spots. The RTAs have been fairly distributed amongst Ayder sub-city and Quiha sub-city since 9 (2.9%) RTAs have recorded from each respectively. The spatial distribution of RTA spots in Mekelle City by the year 2011 is shown in figure 20.

5.2.4.1 Spatial Distribution of RTA Black Spots of Mekelle City in 2011

As described in table 17 and figure 21, 14 places are identified as RTA Black spots in Mekelle City in the year 2011. Comparing to 2010, the number of RTA Black spots have increased by one but the frequency of RTAs occurred in the black spots remain the same as 93.

Table 17: Mekelle City RTA Black Spot areas (2011)

Year	RTA Black Spot area	Black Spot code	No. of RTAs occurred in the Black spot
2011	Adihawsi	12	9
	Air Force	19	5
	Elala	69	6
	Enda Gabir church	74	5
	Enda Raisi Park	78	5
	Lachi	137	8
	May Degene	147	6
	Mekelle Bus Station	155	6
	Mekelle University, Arid campus	158	5
	Mercy School	161	6
	Mesebo Cement Factory	162	7
	Mesebo Mountain	163	8
	Trans Ethiopia	238	7
	Yetebaberut, Endasilassie	245	10
Total	14		93

Source: Compiled from Mekelle City Traffic Office (2012)

According to table 17, a total of 93 RTAs have been recorded from 14 RTA black spots in the city in the year 2011. This infers that, an average of 6.64 RTA occurrences has befallen at every single RTA Black spot in the city in the year 2011. Like in 2010, the highest frequency of RTAs i.e. 10 RTAs occurred in Yetebaberut, Endasilassie area in 2011. In addition to this, half of the RTA Black spots of the city in this year have occurred in the Semen sub-city and its extension. As Kedamay weyane and Hadinet and its extension shared 2 RTA Black Spots each in 2010, Quiha, Adihaki and Hawelti sub-cities compile 1 RTA Black Spot each in the year. Ironically, none of the RTA Black spots have recorded from Ayder sub-city in 2011.

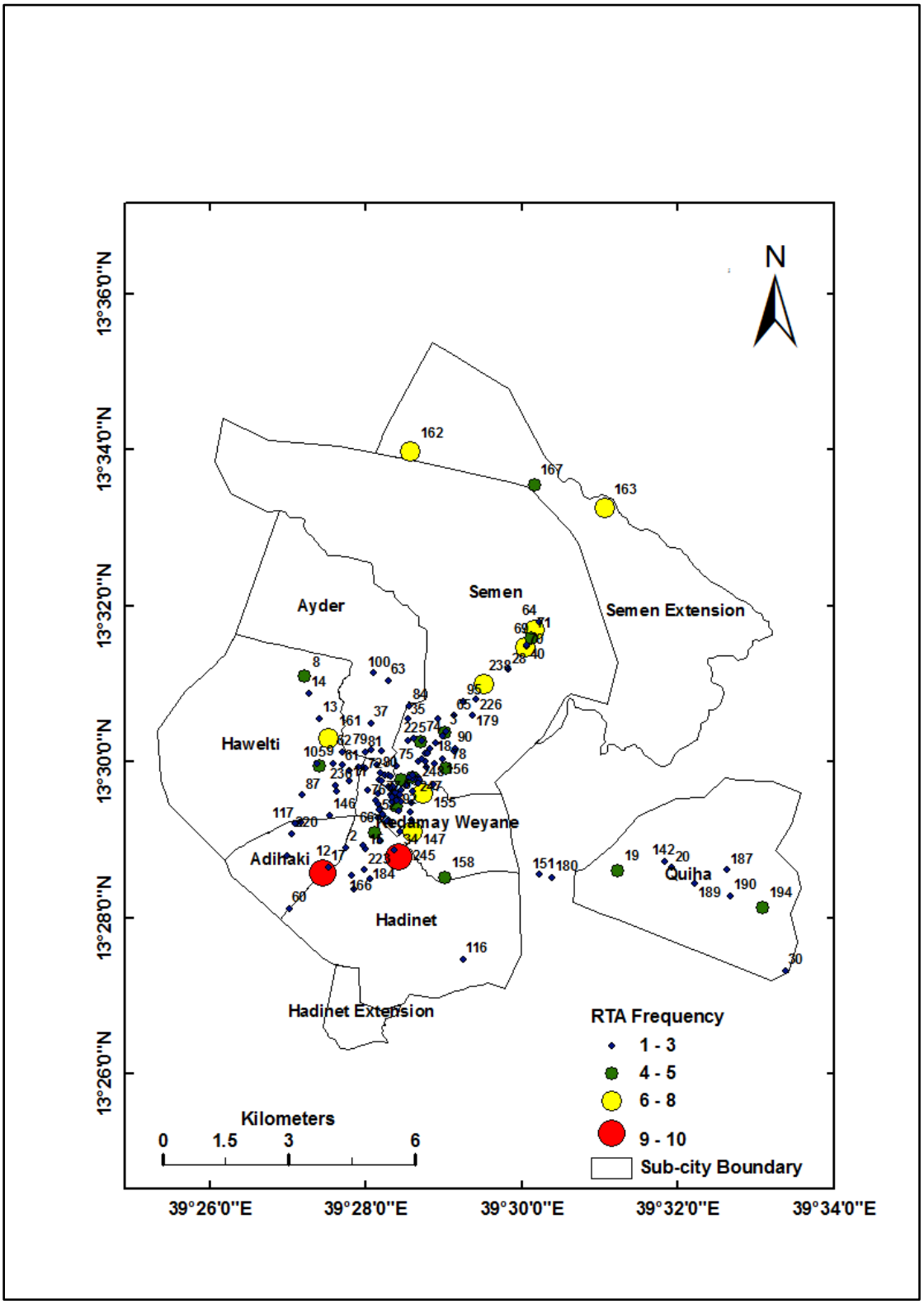


Figure 20: Spatial Distribution of RTAs and RTA Spots in Mekelle City (2011)

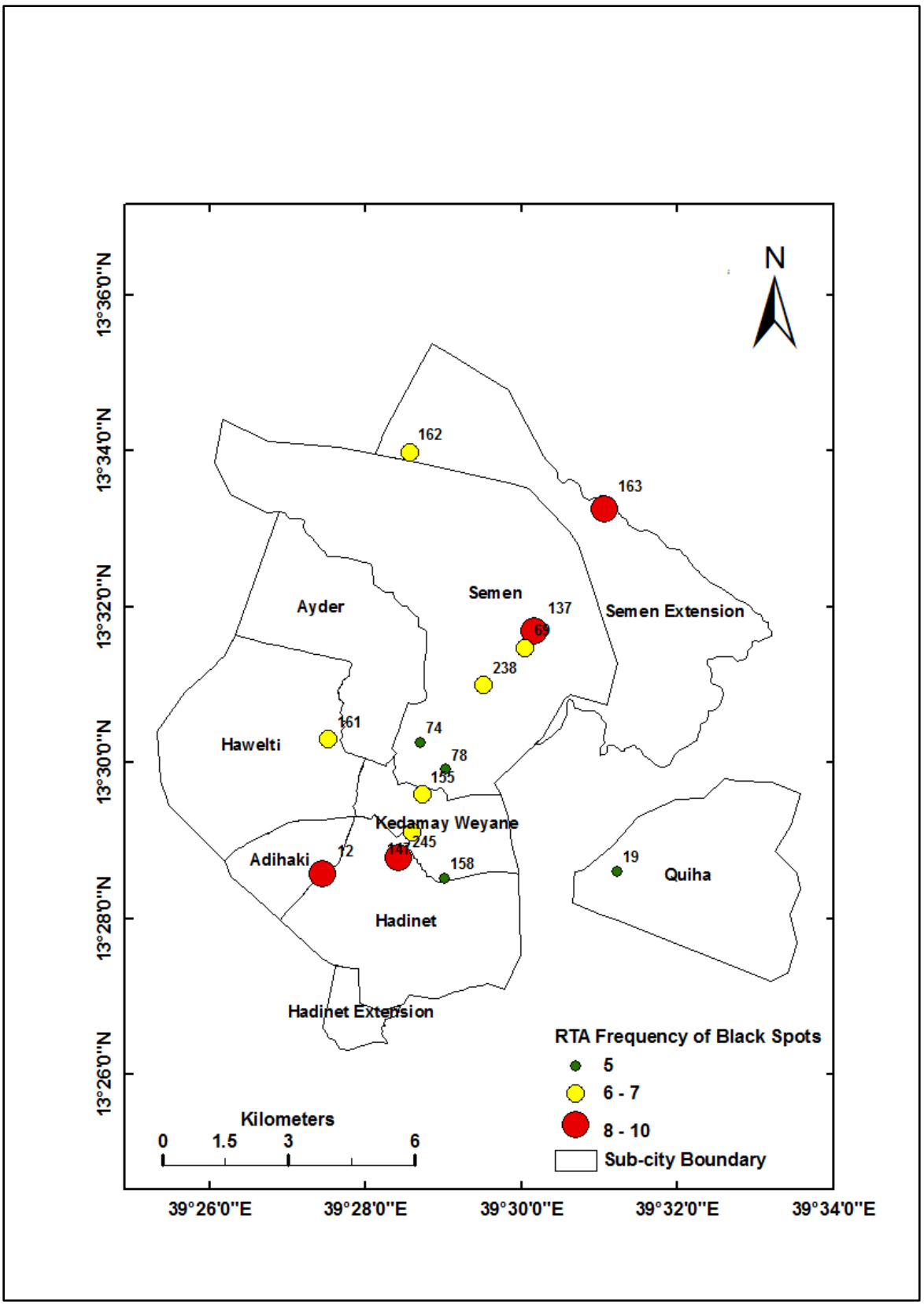


Figure 21: Spatial Distribution of RTA Black Spots in Mekelle City (2011)

5.2.5 Spatial Distribution of all Spatially Identified RTA Spots of Mekelle City From 2008 to 2011

In the last sections prior to this one, it has been discussed that 1161 RTAs have occurred in the city which exhibited in 247 different RTA Spots from 2008 to 2011. The following table 18 recapitulates the total number of RTA Spots and their spatial distribution via all sub-cities.

Table 18: Spatial distribution of total RTA Spots in the Mekelle City (2008 -2011)

Sub-city	Number of RTA Spots	Total RTAs occurred
Semen and its extension	74	472
Kedamay Weyane	73	195
Quiha	29	107
Hadinet and its extension	28	177
Hawelti	27	162
Ayder	9	21
Adihaqi	7	27
Total	247	1161

Source: Compiled from Mekelle City Traffic Office (2012)

Conferring to table 18, Semen and its extension and Kedamay Weyane sub-cities shared the largest number of RTA Spots of the city in the last four years. Semen sub-city and its extension engulfed 74 RTA Spots while Kedamay weyane sub-city constitutes 73 in the study period. This implies that, 147 (59.51%) of the total RTA Spots in Mekelle City are found in Semen and its extension and Kedamay weyane sub-cities. The higher density of roads, larger volume of vehicle and population movements and extensive business activities makes these two sub-cities to take the lion share of the spatial distribution of RTA Spots of the city from 2008 to 2011. The RTA Spots are fairly distributed among Quiha, Hadinet and its extension and Hawelti sub-cities. However, Ayder and Adihaki sub-cities contribute only for 9 and 7 total RTA Spots in the city in the whole study period. Although the number of RTA Spots seems to be similar in Semen and its extension and Kedamay Weyane sub-cities, the resulting RTA occurrences in Semen and its extension is by 2.43 times much higher than in Kedamay Weyane. The spatial distribution of all the 247 RTA Spots and their frequency of RTAs in the last four years are shown in figure 22.

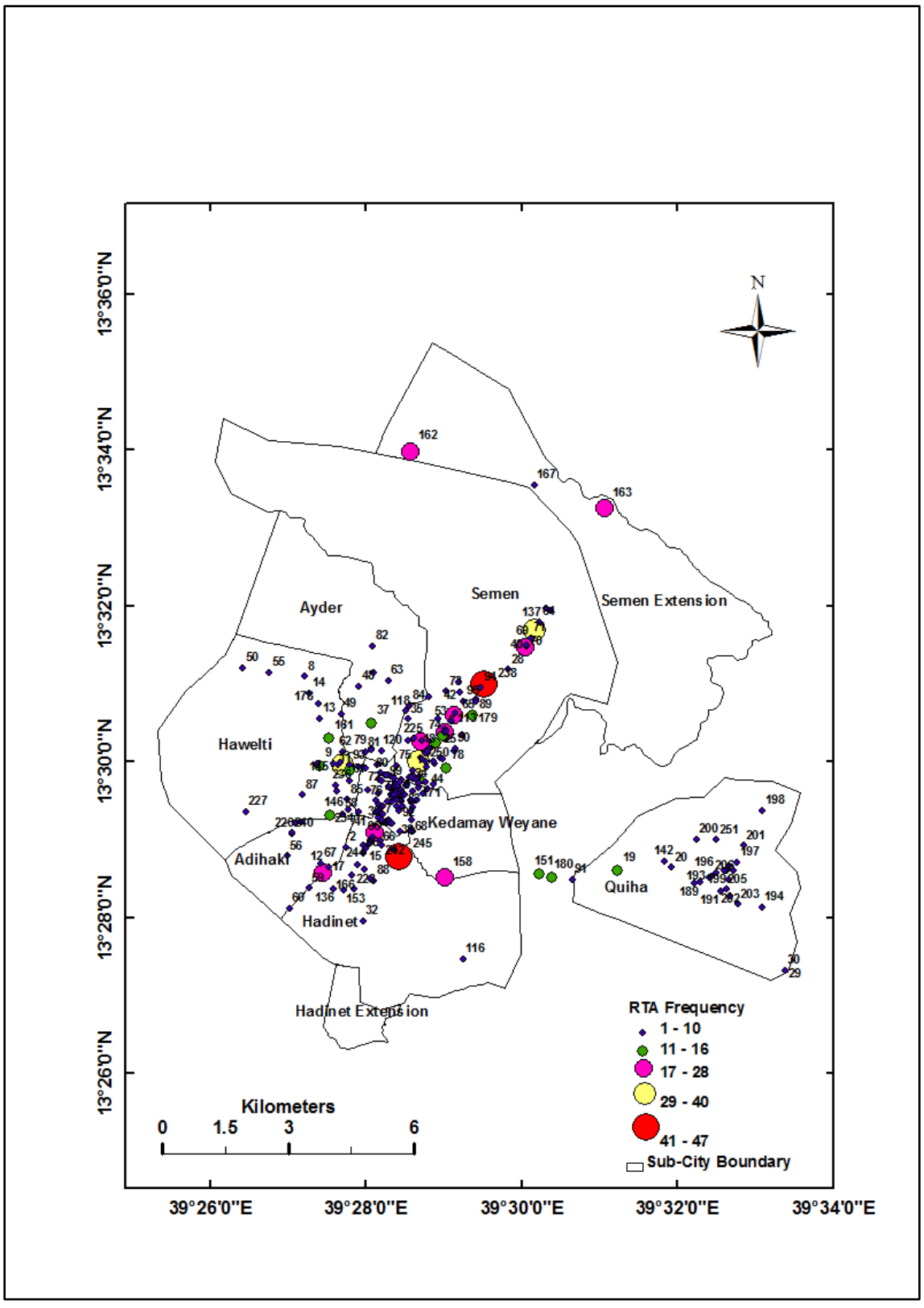


Figure 22: Spatial distribution of all spatially identified RTA Spots of Mekelle City from 2008 – 2011

5.3 Trend of Road Traffic Accident in Mekelle City

5.3.1 Trend in the Occurrence of Road Traffic Accidents

The occurrence of RTAs vary with time as attributed by the variation in the number and quality of vehicles, quality of roads, physical characteristics of roads, weather condition, population size, level of awareness of road users. The frequencies of occurrence of RTAs in Mekelle City also exhibit such fluctuations in this decade due to either of these reasons. As shown in figure 23, more than 1791 RTA occurrences have been recorded on the roads of Mekelle City from 2003 to 2011. According to MZPTO (2007), the first five years from 2003 to 2007 show only 516 road crashes in the city. However, according to our findings, the years from 2008 to 2011 revealed the incidence of 1275 road crashes. This means the occurrence of RTAs in Mekelle City in the last four years from 2008 to 2011 is 2.47 times much higher than the RTAs occurred in the first five years from 2003 to 2007. The RTA incidences of the city have shown an increasing trend in the last decade except in 2004, 2006 and 2010. At an average, about 103.2 RTAs have occurred every year in the city between 2003 and 2007 but the occurrence of RTAs have increased to an average of 318.75 incidences per year from 2008 to 2011. The gradual growth in vehicle and human population in the city contributed much to the increasing trend of RTA frequency in Mekelle City especially from the year 2008 to 2011.

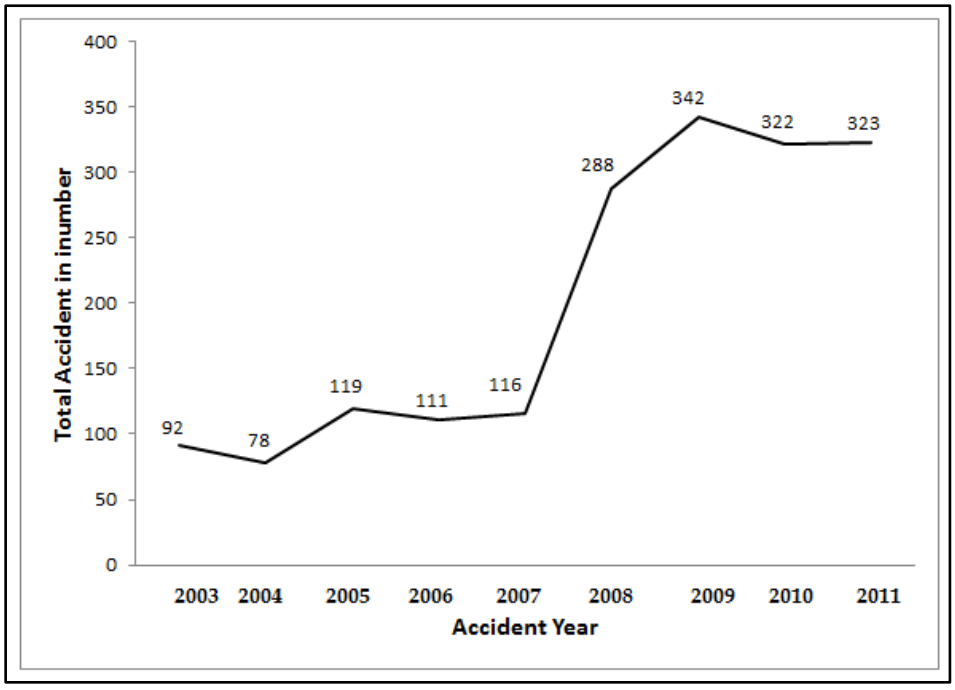


Figure 23: Trend of RTA Occurrences in Mekelle City (2003-2011)

Source: MZPTO (2007) and Mekelle City Traffic Office (2012)

5.3.2 The Spatio-Temporal Distribution and Trend of RTA Frequency among all Sub-Cities of Mekelle City

The frequency of RTAs occurred in Mekelle City from 2008 to 2011 exhibits some variations among the sub-cities. The Table shown below indicates the variation in the vulnerability of Mekelle sub-cities to RTAs.

Table 19: Spatio-temporal variation of RTA Frequency in Mekelle City (2008 – 2011)

Sub-City	Accident Year				Total	%
	2008	2009	2010	2011		
Semen and its extension	109	143	101	119	472	40.7
Quiha	35	34	17	21	107	9.2
Hawelti	40	35	49	38	162	14.0
Hadinet and its extension	36	50	49	42	177	15.2
Ayder	5	0	7	9	21	1.8
Kedamay Weyane	42	14	62	77	195	16.8
Adihaki	5	3	10	9	27	2.3
Total	272	279	295	315	1161	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Semen sub-city and its extension dominated the other sub-cities in the occurrence of RTAs in the city in all years (Table 19). Out of 1161 RTAs, 472 (40.7%) have occurred in Semen sub-city and its extension from 2008 to 2011. Kedamay weyane, Hadinet and its extension and Hawelti sub-cities shared 195 (16.8%), 177 (15.2%) and 162 (14%) of RTAs in the city in the study period respectively. The remaining 107 (9.2%), 27 (2.3%) and 21 (1.8%) RTA incidences have recorded in Quiha, Adihaki and Ayder sub-cities respectively. When a comparison is made based on the RTA occurrences between Semen sub-city and its extension and Ayder sub-city, the RTA incidences in Semen sub-city and its extension is about 22.47 times much higher than the RTAs recorded in Ayder sub-city in the study period. The larger size of the sub-city, the nature of its roads and its function serving as a place of almost all garages in the city which used the roads as places of vehicle maintenance are the main reasons for Semen sub-city and its extension to be the most vulnerable area of frequent RTAs. The spatio-temporal variation of RTA frequency among all the sub-cities of Mekelle is shown in figure 24.

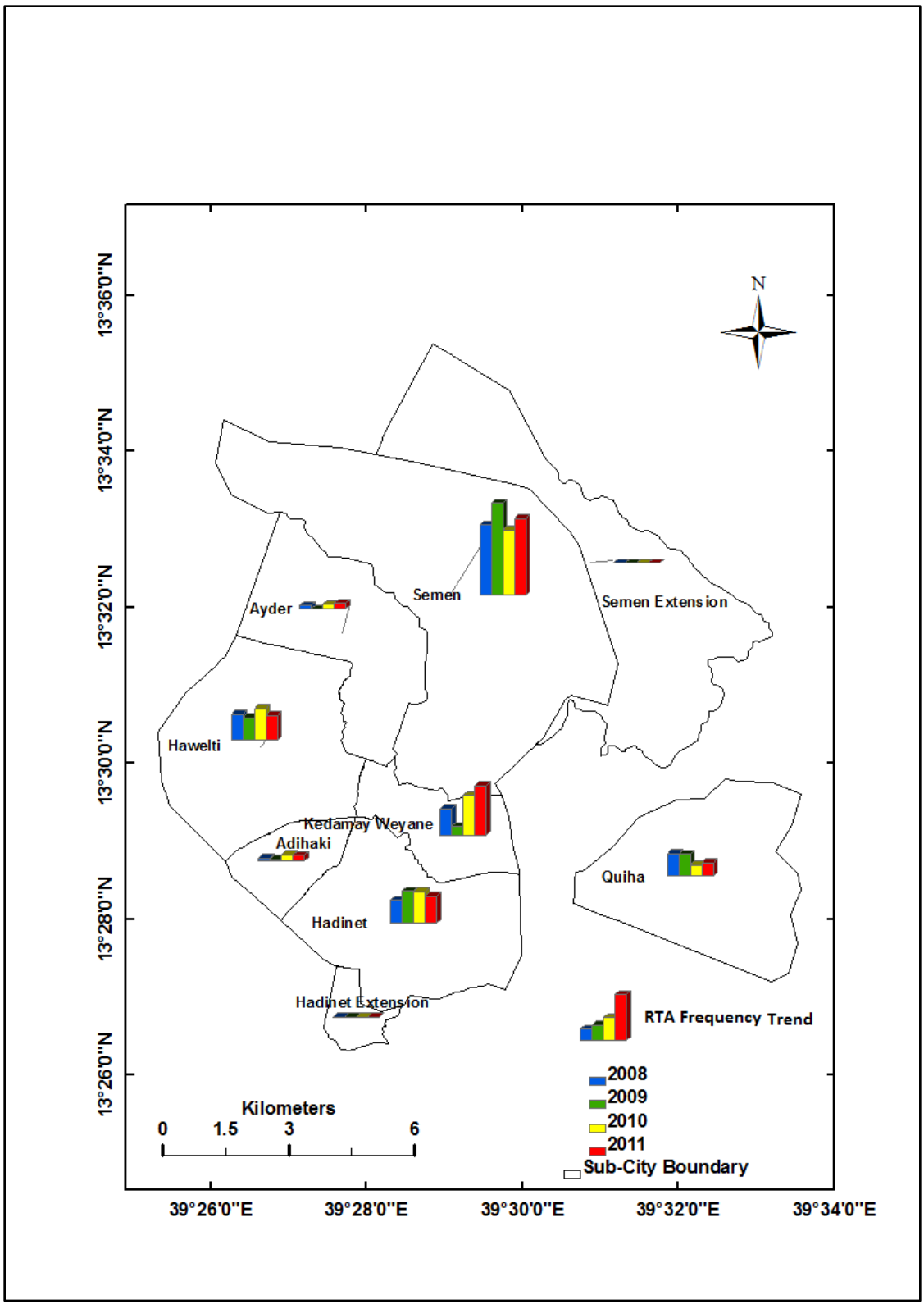


Figure 24: The Spatio-temporal Distribution and Trend of RTA frequency among all sub-cities of Mekelle City (2008 – 2011)

5.3.3 The Spatio-Temporal Distribution and Trend of RTA Frequency in all RTA Black Spots of Mekelle City

The distribution as well as the frequency of RTAs occurred in the RTA Black Spots of Mekelle City exhibits both spatial and temporal variation. As shown in table 20 and figure 25, from the total 247 RTA Spots, 34 different RTA Black Spots have been identified in the city from 2008 to 2011. In addition to this 600 (51.6%) out of 1161 total RTA incidences have occurred in these 34 Black Spots. This implies that an average of 17.64 RTAs have been recorded from each RTA Black Spots in the study period. The frequency of RTA incidences varies from 47 in Trans Ethiopia area to 5 in some city areas. Semen sub-city and its extension constitute 14 different RTA Black Spots followed by Hawelti and Hadinet and its extension sub-cities which constitute 5 RTA Black spots each from 2008 to 2011. In addition to this, Quiha, Kedamay weyane and Adihaki sub-cities constitute 4, 3 and 2 different RTA Black spots in the study period.

Table 20: All RTA Black Spots and Frequency of RTAs in Mekelle City (2008 – 2011)

RTA Black Spot Code	RTA Black Spot	Accident Year				Total RTAs	%
		2008	2009	2010	2011		
238	Trans Ethiopia	16	14	10	7	47	7.8
245	Yetebaberut, Endasilassie	11	12	13	10	46	7.7
137	Lachi	10	8	9	8	35	5.8
172	Mobil	11	18	2	3	34	5.7
61	Dedebit Micro Finance	15	4	11	3	33	5.5
163	Mesebo Mountain	6	6	8	8	28	4.7
158	Mekelle University, Arid Campus	11	4	5	5	25	4.2
69	Elala	3	11	1	6	21	3.5
74	Enda Gabir Church	2	12	1	5	20	3.3
165	Mesfin Industrial Engineering	5	6	5	4	20	3.3
12	Adi Hawsi	5	3	2	9	19	3.2
65	Donbosco	10	2	6	1	19	3.2
66	Dr. Fitsum Hospital	4	7	3	4	18	3.0
162	Mesebo Cement Factory	1	7	3	7	18	3.0
19	Air Force	8	2	1	5	16	2.7
179	Noc	3	6	4	3	16	2.7
212	Saturday Market	1	8	4	2	15	2.5
11	Adi Haqi Market	2	3	5	3	13	2.2
146	Martyrs Monument	2	4	5	2	13	2.2
151	May Shibti	6	1	4	2	13	2.2

RTA Black Spot Code	RTA Black Spot	Accident Year				Total RTAs	%
		2008	2009	2010	2011		
37	Ayder Referral Hospital	4	0	5	3	12	2.0
180	Northern Command	3	5	2	2	12	2.0
18	Agip	1	7	1	2	11	1.8
161	Mercy School	0	2	3	6	11	1.8
237	Total	4	1	5	1	11	1.8
129	Kebelle 18	5	0	4	1	10	1.7
135	Kidane Mihret Church Front	2	5	2	1	10	1.7
142	Maa Garment	2	5	1	2	10	1.7
220	Settlement Area	0	1	6	3	10	1.7
147	May Degene	1	0	1	6	8	1.3
155	Mekelle Bus Station	0	0	2	6	8	1.3
108	Health Station	5	0	0	2	7	1.2
127	Kebelle 17	1	1	1	3	6	1.0
50	City Area	0	5	0	0	5	0.8
Total	34	160	170	135	135	600	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

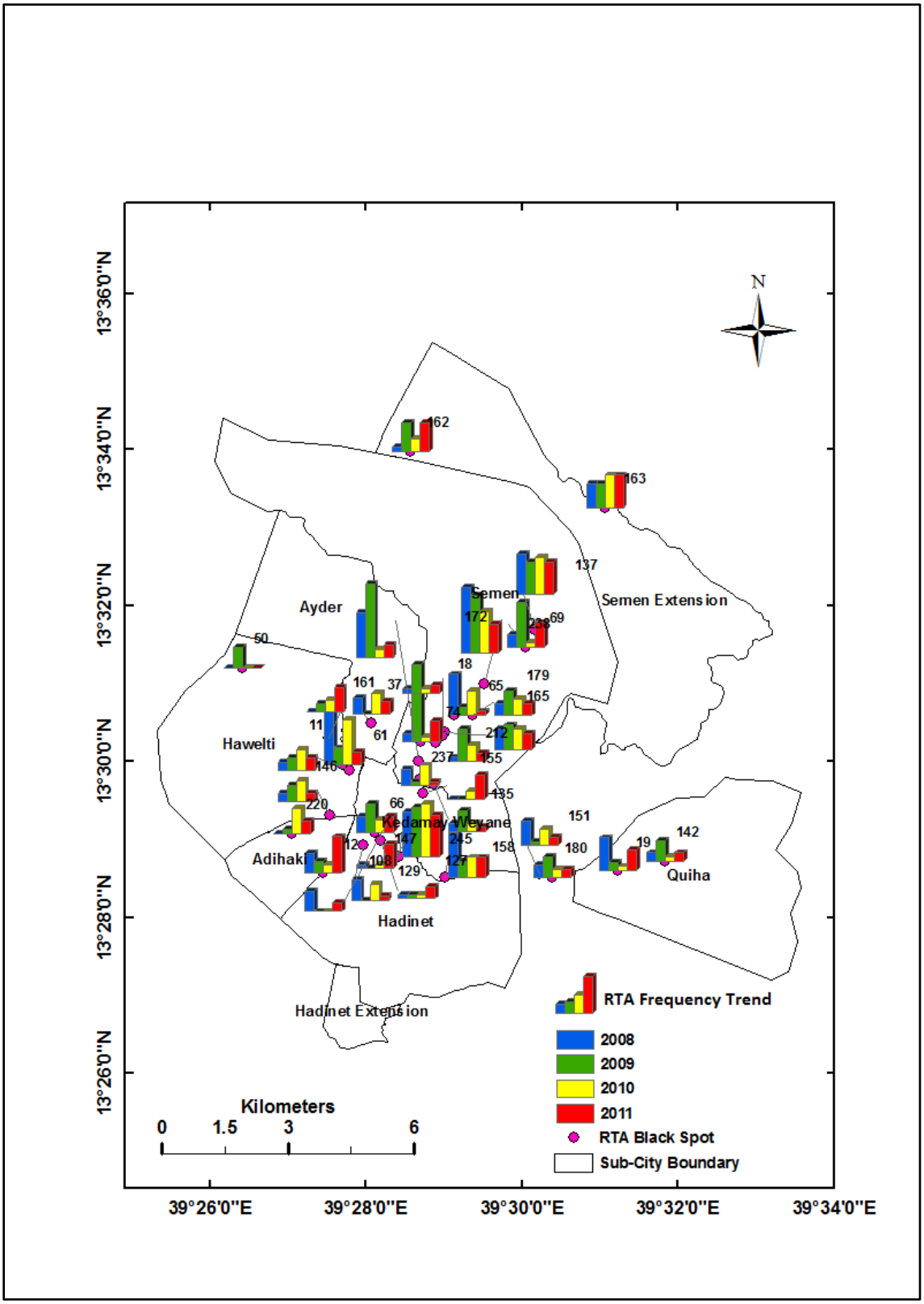


Figure 25: The Spatio-temporal distribution and Trend of RTA Frequency in all RTA Black Spots of Mekelle City (2008 – 2011)

5.3.4 The Spatio-Temporal Distribution and Trend of RTA Frequency in the Top 10 RTA Black Spots of Mekelle City

It is discussed in the previous part that, about 34 RTA Black Spots have been identified in the city from 2008 to 2011. This part however focused only on the Top 10 most severe RTA Black Spots identified in the city in the whole study period from 2008 to 2011. Out of 600 RTAs recorded from all 34 RTA Black Spots of Mekelle City in the study period, 309 (51.5%) have occurred in the Top 10 RTA Black Spots (Table 21, Figure 26). In addition to this, 7 out of the top 10 RTA Black Spots are found in the Semen Sub-city and its extension. The remaining 2 are found in Hadinet sub-city and 1 in Hawelti sub-city. The remaining Sub-cities do not have RTA Black Spots which could be included in the top 10 RTA Black Spot level.

Table 21: Top 10 RTA Black Spots and Frequency of RTAs in Mekelle City (2008 – 2011)

RTA Black Spot Code	RTA Black Spot	Accident Year				Total RTAs	%
		2008	2009	2010	2011		
238	Trans Ethiopia	16	14	10	7	47	15.2
245	Yetebaberut, Endasilassie	11	12	13	10	46	14.9
137	Lachi	10	8	9	8	35	11.3
172	Mobil	11	18	2	3	34	11.0
61	Dedebit Micro Finance	15	4	11	3	33	10.7
163	Mesebo Mountain	6	6	8	8	28	9.1
158	Mekelle University, Arid Campus	11	4	5	5	25	8.1
69	Elala	3	11	1	6	21	6.8
74	Enda Gabir Church	2	12	1	5	20	6.5
165	Mesfin Industrial Engineering	5	6	5	4	20	6.5
Total	10	90	95	65	59	309	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

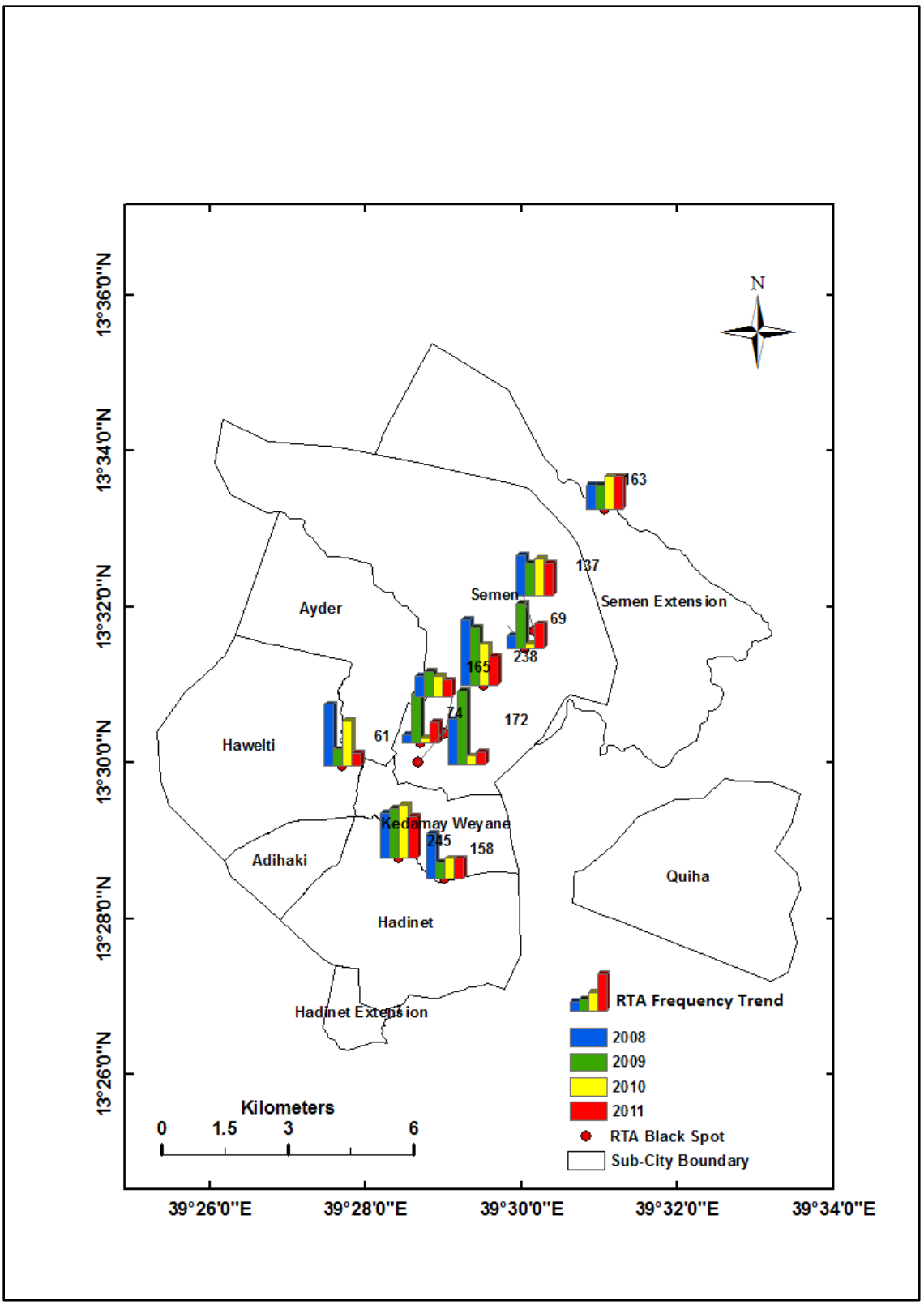


Figure 26: The Spatio-temporal Distribution and Trend in the occurrence of RTA Frequency in the Top 10 RTA Black Spots of Mekelle City (2008 – 2011)

5.3.5 The Spatio-Temporal Distribution and Trend of RTA Frequency in the Consistent RTA Black Spots of Mekelle City

Consistent RTA Black spots are RTA Spots which continues as RTA Black Spots in every study period. In this context, Consistent RTA Black Spots of Mekelle City are identified based on their consistency as RTA Black spot in every year in the study period from 2008 to 2011. Accordingly, only four RTA Black spots are found as consistent RTA Black spots in the city within the study period.

Table 22: Consistent RTA Black Spots and Frequency of RTAs in Mekelle City (2008 – 2011)

RTA Black Spot Code	RTA Black Spot	Accident Year				Total RTAs	%
		2008	2009	2010	2011		
238	Trans Ethiopia	16	14	10	7	47	30.1
245	Yetebaberut, Endasilassie	11	12	13	10	46	29.5
137	Lachi	10	8	9	8	35	22.4
163	Mesebo Mountain	6	6	8	8	28	17.9
Total	4	43	40	40	33	156	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Table 22 disclosed that, Trans Ethiopia, Yetebaberut/ Endasilassie, Lachi and Mesebo Mountain are found as RTA Black spots in all years from 2008 to 2011 in the city and are designated as consistent RTA Black Spots of Mekelle City in this study. Trans Ethiopia is an area where several trucks move, park and get maintenance along the road. Yetebaberut/ Endasilassie is a steep and curvy road and, drivers will have less control of their vehicles when coupled with speed. . Lachi is a two way narrow asphalt road which serves as the only way to the North of Tigray for the incoming and outgoing vehicles of all types. Messebo Mountain is also characterized by steep terrain with short curves. When this is again coupled with speed of the drivers, it increases the frequency of RTAs. These all features make the identified RTA Black spots to be consistent and frequent RTA Spots in the city. The spatio-temporal distribution of Consistent RTA Black spots and their RTA variation is shown in figure 27.

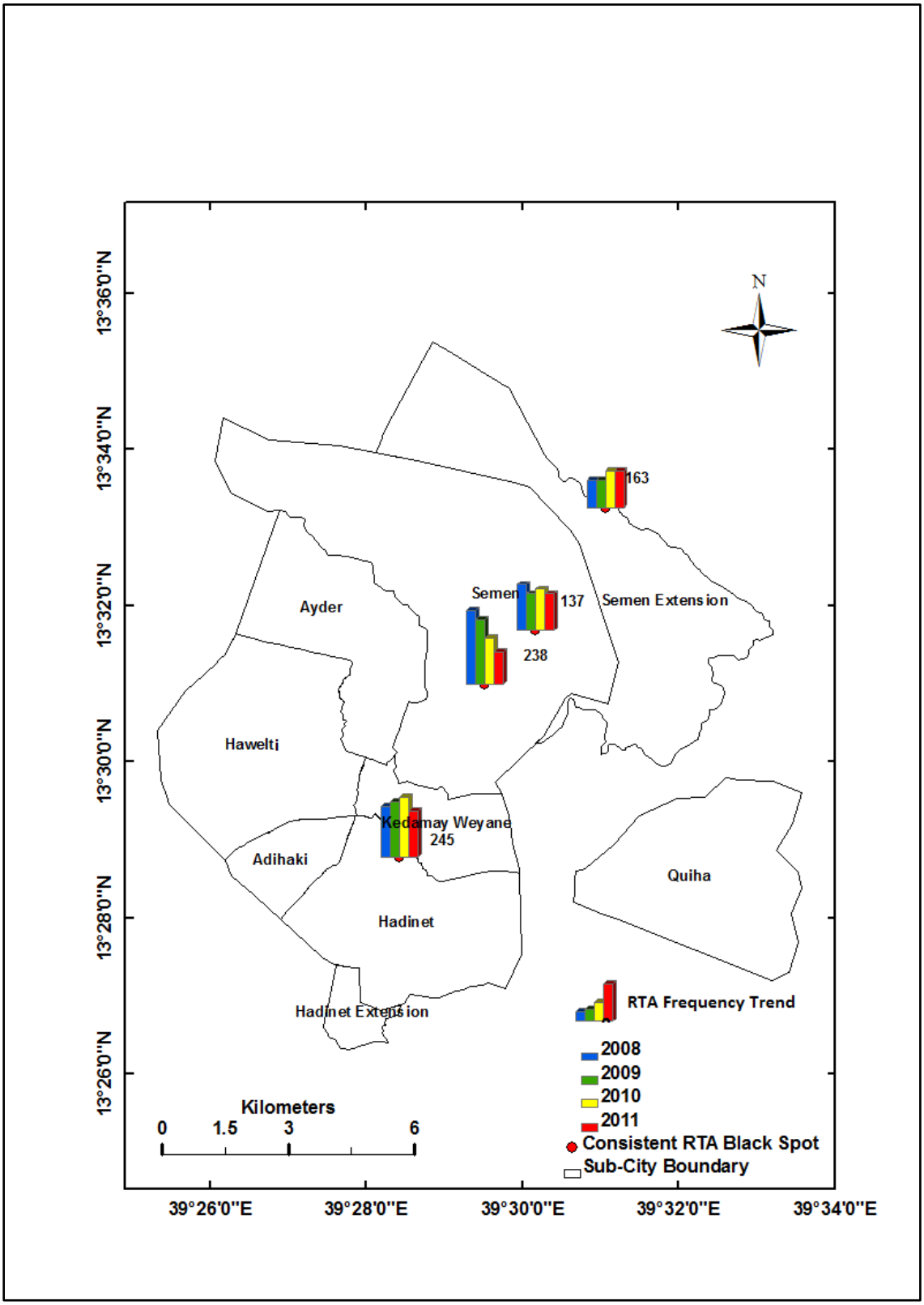


Figure 27: The spatio-temporal Distribution and Trend of RTA Frequency in the consistent RTA Black Spots of Mekelle City (2008 – 2011)

5.4 Causes of Road Traffic Accidents in Mekelle City

There are several causes that result RTAs across all roads in the world. According to Mebrahtu (2002); (Addis 2003; Segni 2007) the major causes of RTA in Ethiopia and its cities include lack of driving skills, poor knowledge of drivers and pedestrians over traffic rules and regulations, violating speed limits by drivers, insufficient traffic law enforcements, lack of timely vehicle maintenance, driving under the influence of drugs and alcohol, failure to observe and respect road traffic signs, failure to give way for pedestrians, failure to give way for vehicles, lack of sidewalks, lack of road traffic signs, improper overtaking, improper turning and excessive loading.

In addition to this, the common and frequently observed causes of RTAs in Mekelle City are also similar to the aforementioned reasons. Seemingly, with some additional variables of causes of RTA, table 23 as shown below describes the current staple reasons of RTA occurrences in Mekelle City.

Table 23: Causes of RTA in Mekelle City (2008-2011)

Accident reason	Accident year				Total	%
	2008	2009	2010	2011		
Missing	15	44	9	3	71	5.6
Brake failure	2	0	0	0	2	0.2
Chasing too close	0	0	0	43	43	3.4
Failure to give way for pedestrian	74	85	57	80	296	23.2
Failure to give way for vehicle	84	121	106	26	337	26.4
Failure to respect the right-hand rule	31	14	0	19	64	5.0
Improper Parking	1	4	4	4	13	1.0
Improper Turning	10	9	32	50	101	7.9
Lack of experience	4	3	3	2	12	0.9
Speed Driving	65	56	108	96	325	25.5
un safe disposal	2	2	3	0	7	0.5
Un Safe Driving	0	4	0	0	4	0.3
Total	288	342	322	323	1275	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

Failure to give way for vehicles, speed driving, failure to give way for pedestrians, improper turning and failure to respect the right-hand rule are the major causes of RTAs in Mekelle City in the study period (Table 23). Failure to give way for vehicles produced 337 (26.4%) RTAs in the study period. In addition to this, the Speed driving, Failure to give way for pedestrians, improper turning and failure to respect the right-hand rule contributed to 325 (25.5%), 296 (23.2%), 101 (7.9%) and 64, (5%) accidents respectively. This shows that the RTAs in the city are mainly characterized with the involvement of vehicles and pedestrians. This phenomenon results in a huge property damages and severe consequences in the life of Mekelle City dwellers.

In addition to this, information collected from some Traffic officers (key informants in this study) have added that, drivers' negligence, failure of pedestrians in using zebra crosses while crossing ways and lesser awareness of the society about RTAs are the major causes of RTA occurrences in the city. Besides, the officers have further identified that, lack of road traffic lights, insufficient number of road traffic signs, limited number and size of side walkways and lower quality of roads played critical role in aggravating the occurrence of RTAs in the city.

5.5 Impacts of Road Traffic Accidents in Mekelle City

5.5.1 Social Impacts of Road Traffic Accident

5.5.1.1 Road Traffic Accident and Sex of Casualties in Mekelle City

It is obvious that, the sex of casualties as being male or female by itself does not have any implication to the destiny of prevalence to RTA incidents. However, other human made factors built blocks of differences among sexes incidence to RTAs. The following Table portrays the distinction among sexes prevalence to RTA in Mekelle City.

Table 24: RTA by sex and accident severity class in Mekelle City (2008-2011)

Accident Severity class	Accident Year								Total			%
	2008		2009		2010		2011					
	M	F	M	F	M	F	M	F	M	F	T	
Fatal Accident	25	12	13	6	28	9	16	10	82	37	119	19.1
Serious injury	50	24	62	22	69	15	37	22	218	83	301	48.2
Slight injury	20	5	61	15	68	11	5	19	154	50	204	32.7
Total	95	41	136	43	165	35	58	51	454	170	624	100.0

Source: Mekelle City Traffic Office (2011)

The number of persons who lost their lives, lost either of parts of their body and visits a hospital due to RTAs were 119, 301 and 204 respectively (Table 24). The data in the table also proves that, males are more frequently vulnerable to road crashes than females in the city. According to the data, 454 (72.75%) males and 170 (27.24%) females were victims of RTAs in the city from 2008 to 2011. This indicates that, males are 2.67 times more prevalent to RTAs than females in Mekelle City. More specifically, males are 2.21 times, 2.62 times and 3.08 times much vulnerable than females to fatal accidents, serious injury and slight injury in Mekelle City respectively. In addition to this, males are more victims of RTAs than females in all accident severity classes and in all years from 2008 to 2011. Such amount of difference among sexes in their prevalence to RTA in Mekelle City is a manifestation of various factors. Since majority of the drivers are males and are the main sources of economies, they are found to be the most victims of RTAs. This gender based difference in RTAs of Mekelle City is similar to the findings of (WHO 2004). A study by WHO (2004) conducted across WHO member countries specified that in 2002, males accounted for 73% of all road traffic deaths, with an overall rate almost three times that for females: 27.6 per 100, 000 for male population and 10.4 per 100, 000 for female population, respectively. Road traffic mortality rates are higher in men than in women in all regions regardless of income level, and also across all age groups. At an average, males in the low-income and middle-income countries of the WHO Africa Region and the WHO Eastern Mediterranean Region have the highest road traffic injury mortality rates worldwide. The gender difference in mortality rates is probably related to both exposure and risk-taking behavior (WHO 2004). In addition to this Addis (2003) have stated that the risk of males to be involved in RTAs is three to four times higher than females in Bahir Dar City.

5.5.1.2 Road Traffic Accident by Accident Severity Classes and by age of casualties in Mekelle City

All age segments may not be equally exposed to RTAs. The economic role and responsibility of the age groups in the community could contribute to the fatality of age groups in road crashes. Table 25, shows RTA by accident severity classes in Mekelle City between the years 2008 to 2011.

Table 25: RTA by accident severity class in Mekelle City (2008-2011)

Accident Severity class	Accident Year				Total	%
	2008	2009	2010	2011		
Fatal Accident	37	19	37	26	119	19.1
Serious injury	74	84	84	59	301	48.2
Slight injury	25	76	79	24	204	32.7
Total	136	179	200	109	624	100.0

Source: Mekelle City Traffic Office (2011)

Out of every 100 RTA casualties in Mekelle City 19 have the probability of death, 48.2 the fate of serious injury and the rest 32.7 the possibility of suffering from slight injury due to RTAs (Table 25). The highest frequency of serious injuries and slight injuries in the city have been exhibited in the years of 2009 and 2010 while the most shocking fatal accidents of road crashes have been unveiled in 2008 and 2010 in the city. In general, 156 road users in the city became victims of RTAs every year from 2008 to 2011. More specifically, 29.74, 75.25 and 51 people suffer fatal accidents, serious injury and slight injury every year in the city between 2008 and 2011. This disaster shows that Victims of fatal road accidents died on the scene or in hospitals. Survivors also suffer from different types of injuries and disabilities which can affect their quality of life. The Victims can be passengers, pedestrians, drivers; they can even be the cause of the accident themselves. As these victims suffer, their families and communities will suffer too; they must sometimes carry the burden of caring for the victims. The prevalence of people to RTAs can be a cause for social insecurity and social crisis. Road Traffic Accidents affect the physical and psychological wellbeing of an individual or groups. In terms of physical injury for instance, the victims of head and spinal injury may be unable to return to their normal lives. They may even require full care at all times. Usually, these conditions are permanent and there are no actual treatments or cures because of the direct injury to the brain and spine, although, there are some rare cases that show physical improvements with limited movement. Often, these patients stay at the hospital for a long time. As for partial injury, there are many examples, for instance, fractures of bones, loss of limbs, abrasions, lacerations and blunt injuries. In addition to this, another serious consequence of road traffic accidents is psychological problems which can have a substantial impact on the survivors of road traffic accidents and their families. Many studies focus on psychiatric disorders that result from RTAs. Some of these studies discuss the short and the long term consequences for those survivors. One

study by Blanchard and Veazey (2001) shows that one-third of young survivors experience a psychological disorder in the early stages and about 25% manifest symptoms for up to 1 year later. Families also suffer from their children's involvement in RTAs. They are considered another hidden victim of RTAs, and need care and support just like other RTA victims or survivors. Families can be affected psychologically and socially. High levels of anxiety, depression, irritability and mood disturbances are the most common psychological symptoms among victims' relatives (Livingston and Brooks 1988).

The distributions of RTAs among different age groups have a serious social impact. All age groups are not equally vulnerable to road crashes in Mekelle City. The data which shows the prevalence of different age categories via accident severity class is only available for the years 2010 and 2011 in the Mekelle City Traffic Office. The analysis is therefore made based on the existing data.

Adults found between the ages of 18 to 30 and 31 to 50 are the most susceptible age groups to RTA in Mekelle City. Adults between 18 to 30 years of age contribute for 168, (54.4%) of road crashes occurred in the city between 2010 and 2011. The severity rate of RTA in all severity classes is much higher in the age groups of 18 to 30 than the others in the last two years. In addition to this, 82 (26.5%) adults aged 31 to 50 years had RTAs in the city during the two years period. Children whose age is below 18 years are also the victims of road crashes in the city. The numbers of children who become victims of RTAs in the city in the last two years are 34 (11%). In addition to this, 25 (8.1%) people whose age is more than 50 also suffered from road crashes in Mekelle City. This panorama which results in the sufferings of children under the age of 18 and productive population between the ages of 18 to 50 drastically affects the wellbeing of the society in the city. This is because, the RTA is obscuring the future of children and complicating the life of the adult in the city. The situation of children and adults as being the frequent victims of RTA in Mekelle City is found to be similar with the case studied by WHO across the globe. WHO (2004) stated that, over 50% of the global mortality due to road traffic injury occurs among young adults aged between 15 and 44 years, and the rates for this age group are higher in low-income and middle-income countries.

Figure 28: RTA Casualty around Mekelle City Bus Station

Source: Mekelle City Traffic Office (2012)

5.5.2 Economic Impacts of Road Traffic Accident

Road Traffic Accidents have multifaceted impacts over the economy of a nation. In addition to the social impacts of RTAs, Mekelle City is also suffering huge economic loss from road crashes. Some of the impacts of RTA have direct economic impact when it is manifested over a property and have indirect influence when it is exhibited on pedestrians, drivers and/or passengers.

Table 26: Estimated cost of RTA in Mekelle City (2008-2011)

Accident Year	Number of accidents resulting property damage	RTA Estimated cost (ETB)	Average cost (ETB)	%
2008	202	2,254,981.90	11163.28	22
2009	260	2,196,355.70	8447.522	21.4
2010	246	1,985,420	8070.813	19.3
2011	246	3,829,220	15565.93	37.3
Total	954	10,265,977.60	10760.98	100.0

Source: Compiled from Mekelle City Traffic Office (2012)

The estimated total cost of RTA in Mekelle City from 2008 to 2011 reaches ETB 10, 265, 977.60 (Table 26). The highest estimated RTA cost has been recorded at ETB 3,829,220, (37.3%) in 2011 while the lowest at ETB 1,985,420 (19.3%) in 2010 in the city. The years 2008 and 2009 exhibited ETB 2,254,981.9 (22%) and ETB 2,196,355.7 (21.4%) RTA cost respectively. This means, the city has lost ETB 10,265,977.6 in the last four years only due to RTAs. Out of 1275 RTA occurrences in the city in the last four years, 954 (74.8%) of the accidents have been accompanied with property damages. Accordingly, every single accident complemented with property damage has led to an average financial loss of ETB 10,760.98 in Mekelle City in the study period. In the other way round, out of every 100 RTAs occurred in Mekelle City, 74.82 of road crash incidences have been involved in property damages and results a financial loss of an average ETB 10,760.98 each from 2008 to 2011. The highest frequency of RTAs resulting property damages i.e. 260, have been recorded in 2009 while the lowest which is 202 incidences in 2008. Mekelle City which is yet struggling to fulfill the needs of its inhabitants due to financial constraints is exhibiting a loss of an average ETB 2,566,494.4 every year only due to RTAs.

Figure 29: Heavy Truck crashed around Gebriel Church

Source: Mekelle City Traffic Office (2012)

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study was carried out to describe the characteristics of RTAs, map places of frequent RTAs, examine the trend of RTA, identify major causes of RTAs, analyze the socio-economic impacts of RTA in terms of time and space and propose appropriate interventions which could help to reduce RTAs in Mekelle City.

This study shows that the frequency and occurrence of RTAs in Mekelle City exhibits variations because of the impact of various variables like age and driving experience of drivers, vehicle service year, vehicle category, road divide, road pavement, road moisture condition and weather conditions. Road Traffic Accidents are randomly distributed in the city in terms of time and space. The RTA Black Spots exhibit the highest frequency of RTA occurrences.

The frequencies of RTAs as well as the socio-economic impacts of RTAs have shown an increasing trend in the study period. Among the various reasons causing numerous RTAs in Mekelle City, failure to give way for vehicles, speed driving, failure to give way for pedestrians, improper turning and failure to respect the right-hand rule contributed much to the misery of road crashes in the city.

Road Traffic Accidents are affecting the dwellers of the city in various aspects. The RTA casualties of the city mainly belong to the productive age groups. Some casualties have lost their lives, others have got serious or slightly injuries due to RTAs. Road Traffic Accidents are also deteriorating the economic wealth of the city.

Thus, we believe that this study contributes much to those who need to understand the general characteristics of RTAs in Mekelle City in terms of time and space and inspire other stake holders to conduct further studies in the field. This study also tries to introduce the application of GIS in the spatial and spatio-temporal RTA assessment works.

6.2 Recommendations

Based on the core findings of this study, the following are recommended.

- Majority of the RTAs in Mekelle City are occurring in the day time especially between 12 pm to 6 pm. Hence, Traffic polices should be assigned in the major roads and RTA Black Spots of the city to ease the volume of vehicles and pedestrians. Vehicle parking across main roads of the city at this specific time which results in traffic congestion needs attention.
- Drivers aged 18 to 30 are more frequently involved in RTAs than the other. The Mekelle City Road Transport and Construction Office which gives the driving license should seriously assess the capability of drivers and monitor the training given to learners by private agencies. Special awareness creation programs should be organized especially for the drivers of this age group so that they could develop the sense of responsibility and ownership.
- Minibuses and three wheeled motors (Bajaj) which are used to convey majority of the city dwellers are found more likely to be involved in frequent RTAs than other vehicle types. Therefore, it is recommended that the implementation of continuous, sudden and special technical investigation as well as training is required on these vehicle types.
- Since two-way roads are more than three times perilous than one-way roads in Mekelle City, the city administration should focus on widening the existing two-way roads and the newly constructed roads should preferably be one-way types. In addition, short junctions and curves were found to be contributing to RTA hence special attention to new road designs is required.
- Speed limits must be placed in shorter distances across asphalt roads since about 71.8% of all the RTAs in the city are exhibited in asphalt pavements and, special follow-up and fine mechanisms should be put in place.
- The vehicle to pedestrian crash is the second most common type of RTA incidences in Mekelle City next to vehicle to vehicle crash. Hence, continuous and participatory public campaigns concerning the use of roads should be given to pedestrians. In line with this, additional pedestrian side walkways must be constructed in the side of roads of the city.
- In order to enable traffic polices control the traffic flow efficiently; road traffic lights should be placed in the major road junctions so that traffic polices could control traffic flow of other roads other than mere in the junctions and, special attention should be given to the RTA black spots already identified.

- Vehicle maintenance service across and at the side of major roads of the city must be banned.
- The prevalence of road casualties is increasing in terms of number and severity form time to time in the city. The time which takes to transport casualties from the place of accident to hospitals or clinics determines the consequence. Therefore, it is recommended that hospitals be more equipped with an emergency vehicle /Ambulances/ to safeguard the destiny of survival of RTA casualties.
- The specific locations of many RTA incidences have not been described in the daily RTA recording format of Mekelle City traffic office. It is therefore suggested that trainings should be provided to traffic officers on how to use GPS to specify where the accident has occurred and the data can easily be used to map and take countermeasures in the RTA risk areas. For this fact, the daily RTA recording format should be redesigned in a way that the Eastings, Northings and elevation of the accident spot can be recorded.
- Since it is vital for RTA analysis, every RTA incidents must be recorded in the daily RTA recording format of the city.
- An effort has to be made to compile and organize RTA data of the city in database software or at least in application software programs like Microsoft office Access or Microsoft office Excel for data retrieval and analysis.
- As it can be clearly seen in this research, under-reporting has been challenging the reliability of the study. Traffic polices should therefore record the accident data and information on the daily RTA recording format consistently to make the RTA data complete, meaningful and rational so that proper safety/protection measures will be put in place.
- Efforts should be made by other researchers to curb the multifaceted impacts of RTA of the city through studying the engineering characteristics of roads and settlements, drivers driving behavior, law enforcements, pedestrians road using behaviors, methods of vehicle inspections, role of private driver learning agencies and the like in Mekelle City.

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Appendix 1

Road Traffic Accident Location (RTA Spot) names and Road Traffic Accident Location (RTA Spot) codes

RTA Location Name (RTA Spot Name)	RTA Location Code (RTA Spot Code)
3rd Police Station	1
Aba Gebremichael School	2
Abebe Garage	3
Abreha Castle	4
Abyssinia Bank	5
Abyssinia Butchery	6
Abyssinia Language Center	7
Adi Ha	8
Adi Haqi	9
Adi Haqi Bridge	10
Adi Haqi Market	11
Adi Hawsi	12
Adi Shim Dihun	13
Adi Shim Dihun Market	14
Adventist School	15
Agazi Hotel, Adi Haqi	17
Agip	18
Air Force	19
Airport Square	20
Alula Avenue	21
Amanuel Clinic	22
Ambassador Hotel	23
Anbessa Bank	24
Araya Degol	25
Aregawi Haile Building	26
Artaele Garage	28
Ashago	29
Ashegoda	30
Aster Kitfo	31
Awash Camp	32
Awash Restaurant	33
Axum Hotel	34

RTA Location Name (RTA Spot Name)	RTA Location Code (RTA Spot Code)
Ayder	35
Ayder Bus Stop	36
Ayder Referral Hospital	37
Baloni	38
Biruh Tesfa Car Wash	40
Bridge	41
Bureau Of Agriculture, Kebelle 05	42
Bureau Of Education	43
Bus Stop	44
Café Area	45
Catholic Church	46
Cement Market	47
Cherkos Church	48
China Camp	49
City Area	50
Commercial Area	51
Commercial Bank Of Ethiopia	52
Crs	53
Customs Office	54
Daero Academy	55
Dagim Amsal School	56
Dalas Hotel	57
Debre Damo Hotel	58
Debregenet Condominium	59
Debri Steep Area	60
Dedebit Micro Finance	61
Dejen Bureau	62
Desta Alcohol Factory	63
Desta Printing Press	64
Donbosco	65
Dr. Fitsum Hospital	66
Dr.Solomon Enquay House	67
Effort	68
Elala	69
Elala Bridge	70
Elala Total	71
Enkodo Traffic Light	72
Enda Denagil	73

RTA Location Name (RTA Spot Name)	RTA Location Code (RTA Spot Code)
Enda Gabir Church	74
Enda Maryam Gugsa	75
Enda Michael Church	76
Enda Milaw Mill, Kebelle 12	77
Enda Raisi Park	78
Enda Rufael Church	79
Enkodo Romanat Bank	80
Enkodo School	81
Factory	82
Fasika Hotel	83
Former Business College	84
Fre Abyot School	85
Garad Building	86
Gebriel Church, Hawelti	87
Gebriel Church, Kebelle 17	88
Gelila Engineering	89
Gereb Bubu	90
Gergembez	91
Geza Gerlase	92
Gofla Restaurant	93
Gomista	94
Gotera Gibrina	95
Hadnet Photo Yemane	96
Hadnet Sub-City Administration	97
Hadnet Sub-City Trade And Industry Office	98
Hakfen	99
Hamiday	100
Harmaz Construction Materials Shop	101
Hashenge College	102
Hatse Yohannes Hotel	103
Hawelti	104
Hawelti Administration	105
Hawelti Hotel	106
Hawzen Square	107
Health Station	108
Hen's Market	109
Hibret Bank	110
Hidmo Restaurant	111

RTA Location Name (RTA Spot Name)	RTA Location Code (RTA Spot Code)
Hill Top	112
Industry	113
Jibruk	114
Justice Office Front	115
Kalamino Campus	116
Kaleb School	117
Health Station, Kebelle 03	118
Kebede Garage, Mesfin	119
Kebelle 03	120
Kebelle 05	121
Kebelle 06	122
Kebelle 07	123
Kebelle 11	124
Kebelle 14	125
Kebelle 16	126
Kebelle 17	127
Kebelle 17 Market	128
Kebelle 18	129
Kebelle 18 Bus Stop	130
Kebelle 19	131
Qedamay Weyane Administration Office	132
Kenema Pharmacy	133
Ketema Limat	134
Kidane Mihret Church Front	135
Kisanet School	136
Lachi	137
Lachi, Sur Construction	138
Lili Beauty Salon	139
Lucy Hotel (Around Romanat Traffic Light Area)	140
Lucy Park	141
Maa Garment	142
Maekel Tigray Hotel	143
Market Area	144
Mars Engineering College	145
Martyrs Monument	146
May Degene	147
May Duba	148
May Gebel	149

RTA Location Name (RTA Spot Name)	RTA Location Code (RTA Spot Code)
May Liham School	150
May Shibti	151
May Siye Snack	152
May Weyni School	153
Medhin Insurance Company	154
Mekelle Bus Station	155
Mekelle Hospital	156
Mekelle Hotel	157
Mekelle University, Arid Campus	158
Mekelle University, Business Campus	159
Menen Hotel	160
Mercy School	161
Mesebo Cement Factory	162
Mesebo Mountain	163
Meserete School	164
Mesfin Industrial Engineering	165
Meskerem Hospital	166
Messebo Abattoir	167
Mihret Bakery	168
Milano Hotel	169
Milkana Café	170
Mizer Avenue	171
Mobil	172
Moloti	173
Muslim Cemetery	174
Mussie Avenue	175
National Hotel	176
Nigiste Saba Hotel	177
Nigiste Saba Kindergarten	178
Noc	179
Northern Command	180
Offices Area	181
Old Municipality	182
Old Semien Wereda Administration	183
Oxen Market	184
Photo Fitsum	185
Qedamay Weyane Market Center	186
Quiha Bus Stop	187

RTA Location Name (RTA Spot Name)	RTA Location Code (RTA Spot Code)
Quiha Donbosco	188
Quiha Hospital	189
Quiha Inda Milaw Mill	190
Quiha Kebelle 01	191
Quiha Maryam	192
Quiha Mill	193
Quiha Police Training Center	194
Quiha Square	195
Quiha Street	196
Quiha, Andnet Park	197
Quiha, Awash Camp	198
Quiha, Genet Hotel	199
Quiha, Hospital(Hewo)	200
Quiha, May Bandera	201
Quiha, Memorial Hotel	202
Quiha, Momona School	203
Quiha, Old Market	204
Quiha, Sunrise Café	205
Quiha, Zemenawi Butchery	206
Red Cross	207
Rest	208
Romanat Square	209
Sabi Hotel	210
Samre Hotel	211
Saturday Market	212
Segenet Hotel	213
Semien Police Office	214
Semien Sub-City Administration Office	215
Senay Zeben Mill	216
Seti Hotel	217
Setoch	218
Setoch Restaurant	219
Settlement Area	220
Sewhi Nigus	221
Sheba Academy	222
Sheba Leather Factory	223
Sheba University College	224
Sheria Court	225

RTA Location Name (RTA Spot Name)	RTA Location Code (RTA Spot Code)
Sino Truck Spare Part	226
Sirawat	227
Sos Kindergarten	228
Sunrise Café	229
Sur Construction Compound	230
Tda	231
Tehagez Building	232
Tekezze Hotel	233
Tesfa Metal Work	234
Tigray Hotel	235
Tigray Stadium	236
Total	237
Trans Ethiopia	238
Turbo (Iveco) Garage	239
Vision Recreation Center	240
Wegahta Bakery	242
Wow Fashion, Selam Avenue	243
Yekatit Hotel, Hadnet Sub-City	244
Yetebaberut, Endasilassie	245
Yordanos Restaurant No.2	246
Ze Slassie Square	247
Ze Yordanos Hotel	248
Zemenawi Barberry	249
Zemenawi Restaurant	250
Ziban Zala	251

Appendix 2

Vehicle Types involved in the RTA occurrences of Mekelle City (2008-2011)

Vehicle type * Accident year Crosstabulation

Count

Vehicle type	Accident Year				Total
	2008	2009	2010	2011	
Missing	17	55	19	12	103
Abay Automobile	0	2	0	0	2
Automobile	0	0	0	1	1
Bicycle	13	17	7	14	51
BMW Automobile	0	0	1	0	1
Bus	7	14	10	4	35
Calabrese Truck	0	0	0	1	1
Coaster	2	2	3	2	9
Crane	0	1	0	0	1
DX Automobile	3	0	3	3	9
FIAT Truck	18	12	4	8	42
Ford Automobile	0	3	3	2	8
FOTON Truck	0	0	2	0	2
FSR	3	3	6	4	16
Heavy Truck	12	16	20	28	76
Horse Cart	7	19	30	14	70
Hyundai	0	1	0	0	1
IFA	1	0	0	0	1
Isuzu	14	11	16	19	60
IVECO Truck	1	1	2	0	4
Jeep Automobile	1	0	0	0	1
Jelly Automobile	0	0	0	4	4
kamaz	0	1	0	0	1
Kamaz	1	0	2	2	5
Lada (4 seat Taxi)	0	3	1	1	5
Land cruiser	16	13	19	29	77
Lifan Automobile	0	1	1	2	4
Loader	1	0	0	0	1
Mazda	0	0	2	0	2

	Mercedes	6	3	6	8	23
	Minibus	41	46	51	57	195
	Mitsubishi	9	5	1	3	18
	Motor bicycle	5	5	2	1	13
	Nissan	4	16	7	8	35
	Nissan Patrol	0	0	2	0	2
	Oral	6	2	2	3	13
	Rosenberg	0	0	1	0	1
	Scania Truck	1	1	1	5	8
	Station Wagon	1	0	1	0	2
	Suzuki	2	0	0	0	2
	Tata	0	0	2	0	2
	Three Wheel Motor(Bajaj)	36	32	34	37	139
	Toyota	30	36	28	21	115
	TOYOTA Hilux	23	20	31	28	102
	Turbo Truck	0	0	0	1	1
	Vitara Automobile	1	1	0	0	2
	Volvo Truck	4	0	2	1	7
	Waz	2	0	0	0	2
Total		288	342	322	323	1275

Appendix 3
Interview Questions

Mekelle University

College of Social Sciences and Languages

Department of Geography and Environmental Studies

Interview Questions prepared for the traffic officers in Tigray Region Police Commission and Mekelle City Traffic Office

Foreword:

This interview is prepared to assemble information which can help to study the causes, impacts, trend and Road Traffic spots of Mekelle City in partial fulfillment for the requirements of the award of masters of Science degree in Geography and Environmental studies specialization in GIS and Remote Sensing. The information that you will provide to me undoubtedly will have paramount significance for the success of the study. The researcher here by kindly requests you to give genuine information. I would like to thank you in advance for your time and cooperation.

Name: _____

Position: _____

1. What are the major causes contributing for the majority of Road Traffic Accident occurrences in Mekelle City?
2. How do you assess the trend of Road Traffic Accident in the city?
3. How is Road Traffic Accident affecting the livelihood of the society in the city?
4. Where the Road Traffic Accidents does frequently occurred in the city?
5. How do you assess the quality and distribution of road infrastructures like quality of roads, number of road traffic lights, road traffic signs, side walkways and cross ways in the city?

6. How is the service year of vehicles engaged in Road Traffic Accidents assessed?
7. How is the technical condition of vehicles in the time of accident inspected?
8. What methods are applied to assess the slope of roads where Road Traffic Accidents occur?
9. How is the price of property damages caused by Road Traffic Accidents estimated?
10. How is the Road Traffic Accident Data recorded?
11. What is done so far to minimize the frequency of occurrence of Road Traffic Accidents and their consequences?

I Thank You!

Girmay Giday